SPECIFICATIONS

FOR

QUADRUPLE-EXPANSION TWIN-SCREW

PROPELLING ENGINES, WITH BOILERS AND AUXILIARY MACHINERY,

FOR

GUNBOAT No. 7,

OF

ABOUT 1,200 TONS CRUISING DISPLACEMENT,

TO MAKE A SPEED OF FOURTEEN KNOTS PER HOUR AT A DISPLACEMENT OF 1,200 TONS.

BUREAU OF STEAM ENGINEERING,
NAVY DEPARTMENT,
WASHINGTON, D. C.

WASHINGTON:
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General arrangement of engines (1 sheet).

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SPECIFICATIONS

FOR

QUADRUPLE-EXPANSION TWIN-SCREW PROPELLING ENGINES,

WITH

BOILERS AND AUXILIARY MACHINERY,

REFERENCE BEING HAD TO THE DRAWINGS ACCOMPANYING AND FORMING PART OF THESE SPECIFICATIONS.

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1. GENERAL DESCRIPTION.

The propelling engines will be rights and lefts, placed in a water-tight compartment. These engines will be of the vertical inverted-cylinder, direct-acting, quadruple-expansion type, each with a high-pressure cylinder 11 inches in diameter; a first intermediate-pressure cylinder 17 inches in diameter; a second intermediate-pressure cylinder 24 inches in diameter; and a low-pressure cylinder 34 inches in diameter; the stroke of all pistons being 18 inches. The collective indicated horse power of propelling, air pump, and circulating pump engines will be 1,750 when the main engines are making about 300 revolutions per minute. All cylinders will be steam jacketed. The high-pressure cylinders will be aft and the low-pressure cylinders forward. The low-pressure cylinders will be so arranged as to be disconnected when working at low powers.

The main valves will be worked by Stephenson link motions with double bar links. The valve gears for the high-pressure and first intermediate-pressure cylinders will be interchangeable, and those for the second intermediate-pressure and low-pressure cylinders will also be interchangeable.

There will be one piston valve for each high-pressure cylinder, two for each first intermediate-pressure cylinder, a double ported slide valve for each second intermediate-pressure cylinder, and one for each low-pressure cylinder.

Each main piston will have one piston rod, with a crosshead working on a slipper guide. The framing of the engines will consist of vertical cylindrical forged steel columns well stayed by diagonal braces. The engine bed-plates will be of cast steel, supported on wrought steel keelson plates built in the vessel. The crank shafts will be made in ~~two~~ three sections, with a dis-connecting coupling between the cranks for the second intermediate-pressure and low-pressure cylinders.

All crank, line, and propeller shafting will be hollow. The shafts, piston rods, connecting rods, and working parts generally, will be forged of mild open-hearth steel.

There will be two condensers made of composition or sheet brass. Each will have a cooling surface of about 1,238 square feet, measured on the outside of the tubes, the water passing through the tubes. For each propelling engine there will be one vertical single-acting air pump worked direct from the main engine. The main circulating pumps will be of the centrifugal type, one for each condenser, worked independently, with an auxiliary air pump worked from each engine. The propellers will be right and left, of manganese bronze or approved equivalent metal.

There will be four main tubulous boilers constructed for a working pressure of 250 pounds per square inch. Each of these boilers will have about 25 square feet of grate surface and 1,000 square feet of heating surface. The total grate surface of the main boilers will be about 100 square feet, and the heating surface will be about 4,000 square feet. There will also be two auxiliary boilers of the single-ended return-fire tubular horizontal type, each with one corrugated furnace, constructed for a working pressure of 160 pounds per square inch. Each boiler will be 7 feet 8 inches outside diameter by 9 feet 10⅞ inches in length. Each auxiliary boiler will have about 21 square feet of grate and about 675 square feet of heating surface.

The total grate surface for the auxiliary boilers will be about 42 square feet, and the heating surface about 1,350 square feet.

The main boilers will be placed in the forward water-tight boiler compartment, and the auxiliary boilers in the after water-tight boiler compartment, as shown in the accompanying drawings. There will be two smoke pipes—one for the main, and one for the auxiliary boilers.

There will be two main feed pumps in the engine room, and one auxiliary feed, fire, and bilge pump in each fire room.

There will be two blowers for the main boilers and one for the auxiliary boilers. They will discharge into main air ducts under the fire room floor, from which a branch duct will lead to the ash pit of each furnace. Means will be provided for closing the ash pits when under forced draft and for preventing leakage of gases out of the furnace doors. The draft of each furnace will be regulated by a damper.

There will be steam reversing gear, ash hoists, an ash ejecting apparatus, a coal hoisting winch, auxiliary pumps, engine for workshop machinery, a distilling and evaporating apparatus, and such other auxiliary or supplementary machinery, tools, instruments, or apparatus as are described in the following detailed specifications, or shown in the accompanying drawings.

2. CYLINDERS.

They will consist of castings of best quality of cast iron, with working linings for the cylinders and valve chests. The cylinder casings will include the valve chests, steam ports and passages, the lower heads, and the various brackets to which the cylinder supports will be attached. The steam and exhaust ports will be smoothly cored to the dimensions shown in drawings, the walls of the passages being strongly stayed by ribs or bolts.

The brackets for securing the cylinder tie rods, and the flanges for bolting the cylinders together will be so faced that when bolted together the centers of the high-pressure and first intermediate-pressure cylinders will be 4

feet 3¼ inches apart; the centers of the first and second intermediate-pressure cylinders will be 3 feet 3½ inches apart, and the centers of the second intermediate-pressure cylinder and the low-pressure cylinder will be 3 feet 4 inches apart, with the axes all in one plane.

All the cylinder casings where bolted together or to the columns shall be bolted by body-bound forged steel bolts.

3. HIGH-PRESSURE CYLINDER CASINGS.

The barrels will be $\frac{11}{16}$ inch thick. Each will have one piston valve. They will be faced and bored, as shown, for the reception of the working cylinder linings, and for the valve chest linings. The brackets at the bottom for attachment of the supporting frames and columns will be well ribbed and faced. There will be flanges cast on the casing, as shown, and faced for bolting it to the first intermediate-pressure cylinder. The walls of the steam passages will be properly stayed. The lower head will be removable. There will be facings, flanged and ribbed where necessary, for the attachment of the cylinder and valve chest covers, steam pipes, exhaust pipes, piston rod stuffing boxes, relief valves, drain cocks, jacket steam and drain pipes, indicator pipes, drain pipes, and oil cups. The unfinished part of the bore will be pickled to remove the scale.

4. FIRST INTERMEDIATE-PRESSURE CYLINDER CASINGS.

The heads will be cast with double walls and the space used as a steam jacket. The barrels will be $\frac{11}{16}$ inch thick. Each will have two piston valves. There will be flanges cast on the casing, faced and fitted for bolting to the high-pressure cylinder and to the second intermediate-pressure cylinder. There will be faced brackets for the supporting columns. There will also be facings for attaching the steam and exhaust pipes, receiver safety valves, receiver live steam pipes, relief valves, jacket steam and drain pipes, piston rod stuffing boxes ; also for indicator pipes, oil cups, and drain cocks. The unfinished part of the bore will be pickled to remove the scale.

5. SECOND INTERMEDIATE-PRESSURE CYLINDER CASINGS.

The heads will be cast with double walls and the space used for a steam jacket. The barrels will be $\frac{11}{16}$ inch thick. Each cylinder will have a double-ported slide valve. There will be flanges cast on the casing for bolting to the first intermediate-pressure cylinder, and brackets faced and fitted for securing tie rods from the low-pressure cylinder.

There will also be facings for attaching the steam and exhaust pipes, auxiliary exhaust pipes, receiver safety valves, receiver live steam pipes, relief valves, jacket steam and drain pipes, piston rod stuffing boxes; also for indicator pipes, oil cups, and drain cocks. The unfinished part of the bore will be pickled to remove the scale.

6. LOW-PRESSURE CYLINDER CASINGS.

The heads will be cast with double walls and the space used for steam jackets. The barrels will be $\frac{11}{16}$ inch thick. There will be brackets cast on the casing, faced and fitted for boxes, for securing the tie rods from the second intermediate-pressure cylinder casings. Each will have one doubled-ported slide valve. There will be faced brackets for the supporting frames, steam and exhaust pipes, receiver safety valves, receiver live steam pipes, jacket steam and drain pipes, relief valves, piston rod stuffing boxes, indicator pipes, oil cups and drain cocks. The unfinished part of the bore will be pickled to remove the scale.

7. CYLINDER LININGS.

They will be of close-grained cast iron as hard as can be properly worked, turned and faced to fit the cylinder casings. Each lining will have a bearing at about the middle of its length and at each end.

The linings will be fitted with a stuffing box at the top to allow for expansion and to make the joint tight between the liner and cylinder casing. The high-pressure cylinder liner will be without a flange at the bottom, but will be accurately fitted to the casing and forced in.

It will be held in place by eight screws each 5/8 inch in diameter, screwed half in liner and half in casing.

The liners for the first and second intermediate and low pressure cylinders will have a flange at the bottom. They will be secured in place by countersunk screws passing through this flange, and tapped into the casing.

The linings, after being secured in place in the castings, will be smoothly and accurately bored to diameters of 11, 17, 24, 34 inches for the high, first intermediate, second intermediate, and low pressure cylinders, respectively, and to a thickness of 5/8 inch, the boring to be done with the cylinders in a vertical position.

The linings will be counterbored at both ends, leaving the working bores 18 7/8 inches long. The unfinished parts of the linings will be pickled to remove scale.

8. CYLINDER COVERS.

They will be made of cast iron, well stiffened by ribs. They will be so formed as to leave as little clearance as practicable.

Each cover will be turned and faced to fit its cylinder casing, and finished on outside and edges of flanges.

The cover of the high-pressure cylinder will be secured to the cylinder casing by 18, the cover of the first intermediate-pressure by 22, the cover for the second intermediate-pressure by 30, and the cover of the low-pressure by 38 steel studs, 3/4 inch in diameter.

Holes will be drilled and tapped for jack bolts and eyebolts.

The thickness of the covers will be 7/8 inch for the flanges and 5/8 inch for body and ribs.

9. CYLINDER CLEARANCES.

Care will be taken that the clearances in the cylinders are made no larger than absolutely necessary. After the engines are set up in place and connected, the volume of the clearance at each end of each cylinder will be carefully measured by filling the space with water or oil, and the result plainly marked on some conspicuous part of the cylinder casing. Marks will also be made on

the crosshead guides showing the position of the pistons when the clearances were measured.

The lineal clearance in each cylinder will be about ⅝ of an inch, divided between the two ends to the best advantage.

10. STEAM JACKETS.

All the cylinders will be steam jacketed around the working linings; the lower heads of all the intermediate and low pressure cylinders will be steam jacketed.

The space left around the working linings for steam jackets will be ½ inch in depth. All ribs will be cored out so as to allow a free circulation of the jacket steam and a free drainage of the water of condensation.

Steam for the jackets will be taken from the main steam pipe in each engine room on the boiler side of each engine stop valve, by a 1½-inch pipe. From this pipe a ¾-inch branch will lead to the high-pressure jacket.

Another ¾-inch branch will lead to the first intermediate-pressure jacket. This branch will have a ¾-inch spring reducing-valve adapted to pressures of from 100 to 160 pounds above the atmosphere.

Another ¾-inch branch will lead to the second intermediate-pressure jacket. This branch will have a ¾-inch spring reducing-valve adapted to pressures of from 40 to 80 pounds above the atmosphere.

Another ¾-inch branch will lead to the low-pressure jacket. This branch will have a ¾-inch spring reducing-valve adapted to pressures of from 20 to 50 pounds above the atmosphere.

Each branch steam pipe will have a stop valve close to the jacket main.

There will be on each jacket steam pipe, on the jacket side of the reducing valve, a ⅝-inch adjustable safety valve adapted to the same pressures as the reducing valves.

A ½-inch drain will lead from the lowest part of each jacket to an approved automatic trap with blow through and by-pass pipes and valves, thence to the lower part of

the feed tank, with a branch to the bilge. Each drain pipe will have a stop valve close to its jacket.

The drainage system of the jacket of each pair of opposite cylinders will be entirely independent as far as the trap discharge, from which point the drains may be in common. All pipes in the jacket drain system will have union joints so as to be easily overhauled, and those from each pair of cylinders will have check valves in them.

11. VALVE CHESTS.

The valve chest of each high-pressure cylinder will be fitted for one piston valve, each first intermediate pressure for two, and each second intermediate and low pressure for a double-ported slide valve.

There will be openings at each end of the piston valve chests for inserting and removing the valves and working linings; the chests will be accurately bored and faced for the reception of the working linings.

There will be an opening at the top and bottom of the second intermediate-pressure valve chest, and one at the side of the low-pressure valve chest for inserting and removing the valve. The seats must be accurately faced for the valves.

Before the insertion of the linings the steam and exhaust passages must be thoroughly cleaned and pickled, and care taken that the passages are nowhere contracted to less than the specified areas.

Each intermediate-pressure and each low-pressure valve chest will have a 1½-inch adjustable spring safety valve of approved pattern. They will be loaded to 130, 80, and 30 pounds, respectively, for the intermediate and low pressure chests.

All valve chests will also be fitted with approved composition drain cocks or valves that may be operated from the working platform, the valves to discharge through pipes into the bilge and feed tanks, with the necessary valves for directing the water to either.

12. VALVE CHEST LININGS.

There will be a working lining at each end of each valve chest for each piston valve. They will be of close-

grained cast iron as hard as can be properly worked, accurately turned and faced to fit the casings, and accurately bored to an internal diameter of 6 inches in the high and first intermediate pressure, leaving the walls ½ inch thick.

They will be forced into place, making all joints perfectly tight, and secured by screws tapped half into the linings and half into the casings.

The steam ports will have alternating right and left diagonal bridges of such a section as to permit of the easy passage of steam, taking up not more than one-fourth of the port area.

The edges of all ports will be finished to a uniform outline.

13. VALVE CHEST COVERS.

They will be made of cast iron, the second intermediate pressure and the low-pressure cover being ribbed as shown.

The flanges will be turned and faced to fit on valve chests as shown. The high-pressure and first intermediate-pressure covers will be finished on the outside, and the second intermediate and low-pressure covers will have the outside and edges of flanges finished. Each lower cover will be faced and bored to receive the valve-stem stuffing boxes.

There will be approved provision for proper oiling of the valve stems.

The lower covers will have the necessary faces for securing the valve-stem guides.

Each high-pressure valve chest cover will be secured by ten, each first intermediate-pressure valve chest cover by nine, each second intermediate-pressure valve chest cover by twenty, and each low-pressure valve chest cover by thirty-six ¾-inch steel studs, with finished wrought iron nuts.

14. PISTON VALVES.

All the piston valves will be of cast iron, the thicknesses to be as shown on the drawings. Each valve will

be made in one piece, the distance between the two pistons being such as to make the steam and exhaust laps as required. Each piston of each valve will be cast hollow, and be fitted with a follower and packing ring of cast iron, as shown on the drawings.

15. SLIDE VALVES.

They will be double-ported, and will be made of cast iron. The face of the valve will be finished to a true plane. All the edges will be finished.

The weight of the valve will be balanced as shown in drawing, the top of the second intermediate-pressure balance piston cylinder connecting with the low-pressure steam chest, and that of the low-pressure with the condenser.

16. VALVE STEMS.

They will be of forged steel, oil tempered, and accurately and smoothly ground where they pass through the stuffing boxes. The high-pressure and first intermediate-pressure will be 1½ inches in diameter at the stuffing boxes and reduced to 1⅛ inches where they pass through the valves, the second intermediate-pressure and the low-pressure being 1⅞ inches in diameter at the stuffing box and reduced to 1½ inches where they pass through the valve. The lower end of each first intermediate-pressure stem will have a shoulder and thread cut on it, and be fitted with a steel nut for securing it to the crosshead. The nuts will have collars recessed in counterbores in the crosshead and will be secured by set screws. A slot will be cut in the thread on each stem and fitted to a feather in the crosshead. The thread on each stem must be sufficiently long to allow a reasonable latitude of adjustment. The high, second intermediate, and low-pressure valve stems take hold directly of the link blocks.

The low-pressure valve stem will take hold of the balance piston at top, as shown.

A split pin will be put through the valve stem to keep the nuts from coming off.

17. CYLINDER RELIEF VALVES.

There will be an adjustable spring relief valve of 2 inches diameter on each end of the high, first and second intermediate, and low-pressure cylinders. The valves and their casings will be of composition. Pipes will lead from the relief valve casings to the bilge with easily broken joints.

These valves will have nickel seats or their equivalent, and the valve fittings will be so constructed that the valves can be easily overhauled without slacking the springs, and so that steam will not come into contact with the springs. The springs will have approved means of adjustment, and will be long enough to allow the valves to open to their full extent without unduly increasing the load. The valves will be guided by loosely fitting wings. The springs will bear on shoulders on spindles which fit loosely in sockets recessed in the backs of the valves These spindles will be so fitted that the valves can be moved by the application of a lever. The valves will be fitted with casings and drain pipes, which will prevent people being scalded by hot water from the cylinders. Suitable fulcrums will be on casings for the application of levers for working the valves; one lever to be furnished. All springs must pass a satisfactory test.

The spring casing of each valve will be fitted with a suitable lock; all locks to have interchangeable keys.

18. CYLINDER DRAIN COCKS.

Each high, first and second intermediate, and low-pressure cylinder will be fitted with a 1-inch asbestos-packed drain cock, placed so as to drain the cylinder thoroughly. The cocks must be perfectly tight without undue friction. The drain cocks of each cylinder of each engine will be worked by a separate lever at the working platform. All the drain cocks of each engine will discharge into a pipe leading to the fresh-water side of the condenser with a branch to the bilge. This pipe will have a stop valve near the condenser, and will have a spring non-return valve, without hand gear, which can open to the bilge discharge when the drain to

the condenser is closed, but which will prevent air entering the condenser at any time. Small drain cocks will be fitted to the lowest parts of drain pipes.

19. ENGINE THROTTLE VALVES.

Each engine will have a 4-inch throttle valve, bolted to the high-pressure cylinder casing.

Each throttle valve will consist of a double poppet valve next the engine, working with a hand wheel and lever. An index attached to the stem of this valve will be graduated to show the opening of the valve in tenths. The stem of the valve will be vertical.

20. PISTON ROD STUFFING BOXES.

They will be made of composition and fitted with Watson's metallic packing, and provided with efficient means of lubrication.

21. VALVE STEM STUFFING BOXES.

They will be made of composition and fitted with Watson's metallic packing, and provided with efficient means of lubrication.

22. PISTONS.

They will be of cast steel and will be dished.

Each piston will have one packing ring 1⅛ inches wide, of hard cast iron, cut obliquely and tongued. The thickness of the packing rings will be ½ inch.

The packing rings will be sprung into position.

There will be sufficient clearance between the piston and cylinder to allow for difference of expansion.

When completed the pistons must be carefully weighed, and no excess of weight will be allowed over that due to the dimensions shown in the drawings.

23. PISTON RODS.

The piston rods will be of forged steel, oil-tempered, 3 inches diameter. They will be turned to fit the pistons, with collars as shown, and fitted each with a composition nut at piston end secured by a screw stop pin. The parallel parts will be smoothly and accurately ground.

Each piston rod will have, at its seating in the piston, a collar of 3½ inches diameter and ¾ inch thick, well filleted and recessed in the piston as shown.

The rod will be tapered at the crosshead end and fitted accurately to the crosshead and secured with a wrought-iron or steel nut, as shown. The nut at the crosshead end will be secured by a set screw.

The piston rod will be kept from turning in the piston and crosshead by stop pins.

24. CROSSHEADS AND GIBS AND BRASSES.

The crossheads will be made of wrought or cast steel; the pins will be 3½ inches in diameter and 4 inches long, and will have a central hole of the size and shape marked on the drawing. Each crosshead will have a wearing slipper working on the guide.

The hole for the piston rod will be accurately bored to fit the taper on the piston rod. The slipper will be of manganese bronze of T section.

The ahead sliding surface will be faced with white metal fitted in dove-tailed recesses and hammered in place. The sliding surface for the ahead guide will be 10½ x 8 inches and for the backing it will be 10½ x 6 inches.

The slipper and crosshead will be bolted together as shown, so that all wear may be taken up.

The second intermediate-pressure crosshead will be made as shown for attachment of the air pump beam links

25. CONNECTING RODS.

The connecting rods, with their bolts and caps will be of forged steel, oil-tempered, finished all over. The caps for the wrist pin end will be of composition. The connecting rods will be 40 inches long between centers, turned 3 inches in diameter at small end and 3¾ inches at large end, with a 1½-inch hole bored through its entire length.

The crosshead end of each rod will be forked to span the crosshead. The brasses will be bored to 3½ inches diameter, and will be 4 inches wide to fit pins.

The crank pin end of each connecting rod will be increased in thickness to 4¾ inches, and in width to 13½ inches. The caps will be 2¼ inches thick at the crown, each to conform to the shape of the connecting rod end; the bolts will be 2 inches in diameter, the heads to be fitted with stop pins, and the upper ends of bolts to be provided with split pins of ample size outside the nuts. The nuts will be of wrought iron, each with a collar washer recessed into the connecting rod head and secured by a set screw. The washer will be kept from turning by a pin.

Composition distance pieces will be fitted between the butt and crown brasses; they will be so fitted as to be removable without taking out the cap bolts, and will be channeled so as to be easily reduced when taking up lost motion. At least two thin tin liners will also be fitted to each rod for a similar purpose.

The caps will each be fitted with one eye bolt for handling.

26. CRANK PIN BRASSES.

They will be accurately fitted to the connecting rod ends and secured by the cap bolts as before specified. They will be fitted with approved white metal in strips, accurately fitted to the crank pins, and properly fitted for distribution of oil. They will be faced with sufficient clearance between crank webs to prevent nipping when heated.

27. CROSSHEAD BRASSES.

They will be accurately fitted to the crosshead pins, and properly fitted for the distribution of oil.

28. ENGINE FRAMES.

Each cylinder will be supported by four wrought-steel columns, as shown in the drawings.

The tops of the columns will be turned and faced to fit the facings and lugs on the cylinders and be secured as shown, and the feet of the columns will be faced to fit the planed surfaces provided for them on the engine bedplate.

The columns will be stiffened by wrought-steel tie rods, as shown. The crosshead guides will be secured to the columns as shown.

29. BEDPLATES.

They will consist each of steel castings of **I** section; the upper and lower flanges will be connected to the web and stiffened by ribs as shown. They will be properly finished and faced for crank shaft brasses and caps, and for the flanges of the supporting frames and columns. The bedplates will be secured to the engine keelsons by 1-inch body-bound forged steel bolts, setting up on raised facings on the lower flange.

30. CRANK SHAFT BEARINGS.

The bearings for the crank shaft will be in two parts, of composition lined with white metal, fitted into dovetailed recesses and hammered in place. Both brasses will be turned cylindrical, with flanges to prevent endwise motion. The lower brass will rest on a composition or cast steel chock to which it will be properly fitted.

The top and bottom brasses will have provision made for circulating water through them, and will be fitted with ample oil channels.

The cap bolts will be of forged steel 1⅝ inches in diameter, each provided with a collar, as shown. One end of each bolt will be threaded and screwed into the engine bedplate.

The other end will be threaded and fitted with finished wrought-iron collar nuts and set screws. The parts beyond the nuts will be squared and each fitted with a split pin.

The caps and brasses will be tapped and fitted with eyebolts for handling.

After the engines are secured in the vessel the bearings will be bored out to perfect alignment if required. They will also be trued on their shafts and any defects made good by scraping to a proper bearing.

The bearing will be so fitted that the only bearing of the journal will be on the white metal surface.

The bottom brasses will be so fitted that they can be removed without taking out the shafts.

31. CROSSHEAD GUIDES.

The guides to take the thrust of the crosshead will be of cast iron. They will be cast hollow for the circulation of water to keep them cool. At the top they will be bolted to lugs cast on the bottoms of the cylinders, and at the bottom to a forged steel cross bar secured to the columns as shown. Cast iron lips will be bolted on each side of each go-ahead guide to take the thrust when backing. The guides will be smoothly and accurately finished, and will be fitted in place to proper alignment. Brass oil boxes will be provided for supplying oil to the guides.

32. VALVE GEAR.

It will be of the Stephenson type, with double-bar links. All valves will be worked direct. There will be one crosshead for the first intermediate-pressure valve stems.

The valve gear will be so adjusted that the mean cut-off in full gear for both ends of each cylinder will be about 0.7 stroke.

33. ECCENTRICS.

They will be of cast iron, each in two parts.

The two parts of each eccentric will be neatly fitted together and secured by two forged steel bolts. They will be bored out to a snug fit on the seatings and turned accurately on the outside to an eccentricity of 2 inches for the high, the intermediate, and the low pressure. The seatings for the eccentrics will be on the crank shafts. The eccentrics will be recessed at each side for the flanges of the eccentric straps. Each backing eccentric will be securely keyed on the shaft, and each go-ahead eccentric will be secured to the corresponding backing eccentric by through bolts in slotted holes, the holes to be filled up after the eccentrics are set.

The eccentrics for the high-pressure and the first intermediate-pressure cylinders will have 2 inches face in-

cluding rabbet, and for the second intermediate-pressure and low-pressure will have faces 2¾ inches.

34. ECCENTRIC STRAPS.

They will be of composition, finished all over, made with flanges to fit the recesses of eccentrics, and with lugs for the clamping bolts and for the eccentric rods. The two parts of each strap will be held together by two forged steel bolts with finished heads, lock nuts, and split pins, and fitted with channeled brass distance pieces. Each strap will be lined with white metal fitted into dovetailed recesses and hammered in place. They will be accurately and smoothly bored to fit the eccentrics both on face and recesses, and be properly channeled for oil.

35. ECCENTRIC RODS.

They will be of forged steel, finished all over. Each rod will have a **T** head secured to its eccentric strap by two forged steel stud bolts with nuts locked in place.

The upper end of each rod will be forked to span the link, and fitted with adjustable brasses, as shown.

The two brasses in the forks of each rod must be fitted accurately in line with each other, and smoothly bored to fit the link pins. The distances from centers of eccentrics to centers of link pins will be 3 feet 7¼ inches.

36. MAIN LINKS.

They will be of the double-bar pattern, of forged steel, finished all over. They will all have the pins for eccentric rods forged on and finished to 11 inches between centers. Extensions of the pins at the ahead motion end of each link will form the pins for suspension rods. Each pair of bars will be secured together by through bolts of forged steel, and thimbles fitted with forged steel nuts well secured with split pins.

The go-ahead half of each link will be divided into ten equal parts marked as follows: **0** will indicate the link in mid position, and 10 in full gear.

37. LINK BLOCKS.

They will be of forged steel, finished all over. They will consist each of a link block terminating at each end in a pair of jaws to span the corresponding bar of the link. The jaws will be fitted with composition gibs finished to the curve of the links, the outer gibs being fitted with keys with screw adjustment.

38. SUSPENSION LINKS.

Each Stephenson link will be suspended from the corresponding arm of the reversing shaft by forged steel suspension links.

The ends of these links will be fitted with brasses and caps on main links and reversing-shaft arms.

39. VALVE STEM CROSSHEADS AND GUIDES.

The first intermediate-pressure valve stems will have a cast-steel crosshead, the crosshead taking hold of the link block directly. The boss of each arm of each crosshead will be bored to receive the valve stem, secured as heretofore specified. The valve-stem guides will be cast-steel brackets, bolted to the valve chest covers on the high-pressure and intermediate-pressure cylinders, and to the valve chest on the low-pressure cylinder. The high-pressure, the second intermediate-pressure, and the low-pressure valve stems will take hold of the link blocks directly.

40. REVERSING GEAR.

The reversing gear for each engine will consist of a steam cylinder and a hydraulic controlling cylinder, acting directly on an arm fixed on the reversing shaft. The steam piston rod will be secured to a steel crosshead connecting with the arm on the reversing shaft. The piston rod will pass through the controlling cylinder with uniform diameter. The valve of the steam cylinder will be of the piston pattern, of composition, working in a composition-lined valve chest. There will be a by-pass valve on the hydraulic cylinder, which will be worked by a continuation of the stem of the steam piston valve.

These valves will be worked by a system of differential levers, the primary motion being derived from the hand lever on the working platform and the secondary motion from a pin on the reversing arm, all parts being so adjusted that the reversing engine shall follow the motion of the hand lever and be firmly held when stopped. There will be a stop cock in the by-pass pipe of the hydraulic cylinder, and a pump for reversing by hand will be connected to the hydraulic cylinder, with its lever convenient to the working platform. The by-pass pipes will be connected to the valve box of the hand pump in such a way as to leave the hand arrangements always in gear. The piston of the hydraulic cylinder will be packed by two cup leathers. Steam for the reversing engine will be taken from the auxiliary steam pipe.

41. REVERSING SHAFTS.

There will be one forged-steel reversing shaft for each engine. It will have six arms, two for the reversing engine and one for each link. The shaft will be supported by suitable bearings. Each reversing arm for the links will be made with a slot fitted with a cast-steel block, to which the suspension rods will be attached. Each block will be adjustable in the slot of its arm by a screw and hand wheel with approved locking device, and will be fitted with a suitable index. The slots in these arms will be so arranged that the links may always be thrown into full backward gear irrespective of the position of the block in the slot; and the length of the slots will be such that the cut-off may be varied from about 0.5 to 0.7 of the stroke. All the arms will be neatly fitted and keyed to the shafts.

42. EXHAUST PIPES.

The exhaust passages from the high-pressure steam chest to first intermediate-pressure steam chest will be cast in the casings of these two cylinders. The exhaust passage from the first intermediate to the second intermediate will be cast with the casing of the second intermediate cylinder extending around the barrel of the cylinder.

Two copper exhaust pipes, one on each side, will lead from the second intermediate-pressure to the low-pressure steam chest. The pipe on the inboard side will be 7 inches internal diameter, and be provided with a straight-way valve placed as close to the second intermediate-pressure steam chest as possible. The pipe on the outboard side will be ~~21~~ $7\frac{1}{2}$ inches in diameter, with a branch of this size running to the condenser. Beyond this branch and extending to the low-pressure steam chest the diameter will be 7 inches. Straight-way valves will be provided so that the exhaust steam may be shut off from either the condenser or the low-pressure steam chests. The exhaust pipe leading from the low-pressure steam chest to the condenser will be 12 inches in diameter.

43. REVERSING SHAFT BEARINGS.

The brackets will be forged on the columns, and be fitted with bottom brasses and composition caps, which will be bored to fit the journals of the shafts.

The caps will be secured with bolts and lock nuts.

44. WORKING PLATFORMS.

The floors on the inboard side of each main engine, between the high and intermediate-pressure cylinders, will be conveniently arranged to serve as working platforms. The counter, revolution indicators, clocks, gauges, telegraph dials, and other engine room fittings will be so placed near the working platforms as to be in full view while working the engines. Speaking tube mouth-pieces and telegraph levers will be conveniently placed.

45. WORKING LEVERS AND GEAR.

There will be at each working platform the following hand gear, viz :

One reversing lever.

One hand wheel for letting live steam into first intermediate valve chest.

Four cylinder drain-cock levers; hand-reversing pump lever ; throttle-valve lever and wheel; bleeder-valve hand wheel; reversing-engine stop-valve hand wheels for steam and exhaust.

Reversing and drain cock levers will have spring latches of "locomotive pattern." The latches on reversing levers will be of the best type and subject to the approval of the Bureau of Steam Engineering.

46. SHAFTS.

All the crank, line, thrust, and propeller shafts will be of forged steel. Each length will be forged solid in one piece, and will have a hole drilled axially through it and through the crank pins.

All shafts will be finished all over. They will be supported as shown.

47. CRANK SHAFTS.

There will be three sections of crank shafts for each propelling engine. The forward and after sections will each have one crank, and the middle section will have two cranks. Each crank will have a throw of 9 inches. The forward section of the shaft will have a T-piece forged on the after end for a disconnecting coupling, as shown in the drawing. Each end of the T-arms will be bored with a conical hole for the reception of the coupling pins. The distance between the centers of these pins will be 18 inches. The middle section will have a similar T-piece on the forward end and a coupling forged on the after end. The after section will have a coupling forged on each end. The crank pins will be 6½ inches in diameter and 7½ inches long.

The crank webs will each be 7¼ inches wide, with a thickness for the low presure of 3¼ inches, the second intermediate pressure 3½ inches, the first intermediate 3¾ inches, and the high pressure 4 inches. The webs to be chamfered as shown on the drawing. The length of the forward section will be 3 feet 10⅛ inches, the middle section 7 feet ½ inch, and the after section 3 feet 10⅝ inches.

Each coupling disk will be 1⅝ inches thick and 13 inches in diameter.

There will be a raised seating on each section of shafting for the eccentrics. The crank pins must be accu-

rately parallel to the main journals. All journals are to be smoothly and accurately turned, and when finished will be tested and their accuracy proved. There will be a hole 3¼ inches in diameter bored axially through each shaft and 3½ inches in diameter through crank pins of engines. When bolted together the cranks of each engine will be at angles of 90° to each other; the first intermediate to follow the high-pressure, and the second intermediate-pressure to follow the first intermediate-pressure, and the low-pressure to follow the second intermediate.

The ends of the hole in each crank pin will be closed by a brass plate fastened on with countersunk screws.

One radial ½-inch hole will be drilled in each crank pin from the outside of the bore.

The various lengths of the crank shafts will be coupled to each other by six 1⅝-inch forged steel bolts in each pair of couplings. All holes in each coupling will be drilled or reamed to template. The bolts will be finished to fit the hole snugly, and each fitted with wrought-iron nut and split pin.

A worm wheel for turning the shaft will be fitted where directed.

48. THRUST SHAFTS.

They will be 5⅞ inches in diameter, about 12 feet 6 inches long over all, with 2⅞-inch axial holes. Each shaft will have eight thrust collars 1⅛ inches wide, with spaces of 1⅝ inches, the collars to be 8⅞ inches outside diameter. There will be coupling disks forged on the forward and after ends 1⅝ inches thick and 13 inches diameter.

The bolt holes in the couplings will be drilled or reamed to template, and will be spaced the same as those in the crank-shaft couplings.

49. PROPELLER SHAFTS.

The propeller shafts will each be in two lengths. A 3-inch hole will be bored in both sections of shaft.

The forward section of each shaft will be about 19 feet long and 6⅛ inches diameter, cased with composition ½

inch thick at the bearings and ⅜ inch thick elsewhere. The casing will be shrunk and pinned on, and must be water-tight. The casings must be accurately and smoothly turned to form journals.

The after end of forward section will be tapered to fit a sleeve coupling.

The after section will be about 27 feet long and 6⅛ inches diameter, and will be tapered at the forward end to fit a sleeve coupling. It will have a composition casing which will be ½ inch thick where it passes through the bracket bearing, up to and beyond the fair-water casing, and which will enter 1 inch into the propeller boss.

This section will be well painted, and the exposed part then covered with two thicknesses of insulating tape, overlapping, and wound from the after end.

The after end will be tapered to fit the bore of the propeller boss, and will be fitted for two feather keys.

The hole in this section of the shaft will be 3 inches diameter, except in that part passing through the propeller hub, where it will be tapered so as not to reduce the thickness of the metal around the hole.

There will be a water-tight plug in each end of each section of propeller shafting.

The two lengths of each propeller shaft will be coupled to each other by a sleeve coupling 2 feet 4¼ inches long and 9 inches in diameter. It will be bored with a conical hole 6⅛ inches in diameter at the ends and 5½ inches at the middle. It will be secured to the forward and after sections of the propeller shaft by two feather keys at each end, 14 inches long by 1 inch thick and 1½ inches wide, and by one cross key in each section of the shaft. The cross key will have a section of 3⅛ inches wide by 1¼ inches thick.

There will be at the forward end of the after section of each propeller shaft a cast-steel casing to form a fair waterline from the end of the stern tube to the shaft, as shown in drawings. The casing will be finished on the outside and bored to fit the shaft and couplings.

The shaft, couplings, and casings will be well coated with the same composition as the hull.

50. LUBRICATION.

All working parts of the machinery will be fitted with efficient lubricators, each with a sufficient oil capacity for four hours' running. Each lubricator to be fitted with a tube leading to the wipers on the moving parts, or tubes in the bearings and guides. Each tube from the lubricators will be fitted with a valve adjustment and a sight feed with a well protected glass tube.

There will be in the engine room hatch for each engine a 5-gallon oil tank, well tinned on the inside, and fitted with a glass gauge, filling pipe, and air cock. Each tank will be connected to all the lubricators on its engine by ½-inch brass or copper pipes, as may be directed, the tank to be placed in such a position that oil will flow to each lubricator.

Unions will be fitted where necessary, so that the oil pipes may be quickly taken down and cleaned, and each pipe will be connected to the bearings by a union joint. Each main crank pin will be oiled by cups carried on the connecting rod—taking oil from wicks overhead; the oil to be carried to the crank pins by brass pipes secured to the connecting rods. These pipes will have union joints where connected to oil cups.

Each main crosshead journal will take oil from an overhead wick cup.

Each crosshead guide will be oiled by pipes connecting with holes leading to about the middle of each guide.

Pipes, fitted as above specified, will lead from the lubricators to the following parts of each engine: Piston rods, valve stems, valve links, and reversing shaft.

Each balance piston and each piston valve will have a globe oil cup, placed sufficiently high to insure the oil running where desired without regard to the trim of the vessel.

The upper end of each eccentric rod will carry an oil cup on each fork; these cups to take oil from pipes leading from an oil cup attached to the suspension rod of the link near the rock-shaft arm pin. The link-block pins will be lubricated by wiper oil cups, fed from fixed cups overhead.

Each eccentric will have a long oil cup fed by a drip pipe, so arranged that the eccentric will be lubricated in all positions.

There will be a small oil tank, with glass gauge, placed in a convenient position, and connected by pipes with a closed oil box at each crank-shaft bearing, so that when necessary oil can be supplied to the journals under a head. From each of these boxes two tubes will lead to the bearing, each with valve adjustment, and with a sight feed with a well-protected glass tube.

There will be fitted to each main steam pipe, close to each high pressure valve chest, an approved steam sight-feed oil cup of one quart capacity, with gauge glass. As far as possible all the oil for the moving parts of each engine, except main bearings, will be supplied from one oil box on the cylinder with separate valve, sight feed, and pipe for each part to be oiled. There will be a steam sight-feed cup on each circulating, blower, feed and bilge pump engine. Each blower engine will have a continuous automatic lubricator of approved pattern. All working parts for which oil cups are not specified or shown in drawings will have oiling gear of approved design, such that they can be oiled without slowing. All the oiling of each auxiliary engine will be done by one oil box where practicable. All fixed oil cups will have hinged covers, with stops to prevent being opened too far. Moving oil cups, where necessary, will have removable covers. The supply of oil to various parts is to be easily regulated. All oil cups and their fittings, except such as are cast on bearings, will be of finished cast brass, or of sheet brass or copper, as may be directed, with all seams brazed.

51. OIL DRIPS.

All fixed bearings will have drip cups cast on where possible, otherwise they will be of cast brass, properly applied. All moving parts will have drip cups or pans cast on engine frames where directed, otherwise to be substantially made of sheet brass or copper, with brazed seams. All drip cups will have drain pipes and cocks of

at least ½ inch diameter, which can be used while the engines are in operation.

52. JOURNAL BOXES.

All journals or moving parts of iron or steel will run, unless otherwise specified, in composition boxes. These boxes will be lined with approved anti-friction metal where directed. All adjustable bearings will be provided with channel brass chipping pieces, securely held in place and easily removable.

53. MANDRELS FOR WHITE METAL BEARINGS.

Hollow cast-iron mandrels will be furnished for forming the white metal linings of crank pin, crank shaft, line shaft, and thrust bearings. All these will be smoothly and accurately turned to size, and packed so as to be perfectly protected.

54. STUFFING BOXES.

All iron boxes will be bushed with composition. All glands will be of composition and fitted with approved means of adjustment while the engines are in operation, and those not fitted with pinion nuts and spur rings will have lock nuts and split pins. Watson's metallic packing will be fitted in stuffing boxes of all piston rods and valve stems of main and auxiliary engines. For piston rods and valve stems over 1¼ inches in diameter, the packing will be in at least two independent sections; for piston rods and valve stems between ¾ and 1¼ inches diameter, it will be made in one section.

55. BOLTS AND NUTS.

All bolt heads and nuts less than 3 inches, except in special cases, will conform to the United States Navy standard. Screw threads on bolts and nuts must in all cases conform to the above standard. All finished bolts, except as directed, will be kept from turning by dowels or other suitable devices. This specification is intended to apply to all pumps and auxiliary engines, as well as to parts of the main engines and boilers.

The nuts of all bolts on moving parts and on pillow blocks, and elsewhere as shown, will be locked, and the bolts will extend beyond the nuts, without threads, and will be fitted with split pins.

56. THRUST BEARINGS.

Each thrust-bearing pedestal of cast iron will be bored out to receive the lower part of bearing, and firmly bolted to the seating provided. The bearing will be in two parts, of cast iron, with white metal linings. The lower part will be finished to fit the pedestal. The upper part or cap will be separated from the bottom by composition distance pieces, and will be fitted in place with wrought-iron dowel pins, fitting snugly in holes in the lower part of bearing. The cap will be faced to fit longitudinal recesses in the upper flanges of pedestal, and will be held down by bolts, body bound in pedestal, but with slotted holes in cap. Each cap will have a box cast on top with a hinged cover.

The end and side walls of the pedestal will form an oil trough, from which there will lead an oil hole to each collar and each recess, the white metal being properly channeled for distribution of oil. Inside this trough, both forward and abaft the thrust collars, will be a composition bearing for taking the weight of the shaft. The cap for this bearing will be of cast iron lined with white metal. These bearings will be adjustable vertically by wedges with regulating screws.

At each end of each thrust bearing there will be a divided stuffing box and gland to prevent escape of oil. At the bottom of each thrust bearing there will be a fore and aft channel connecting all the bearing recesses, the connecting holes to each of at least 1 square inch in area; a drain cock will be fitted at each end.

The oil trough will also be fitted with a cooling coil. There will be four adjusting screws, two at each end of the thrust-bearing pedestal for adjusting the bearing fore and aft. The caps will be fitted with eyebolts for convenience of handling.

57. JACKS FOR COUPLING BOLTS.

A hydraulic jack of approved pattern will be fitted for withdrawing the bolts of the shaft couplings.

58. STERN TUBE BEARINGS.

Each stern tube will be finished as follows: It will be made of mild steel with internal cast steel rings at each lignum-vitæ bearing. Fitted to these rings there will be a composition bushing, the inner one made in halves, the joints to be in a horizontal plane when bushing is in place. These bushings will be fitted with sections of lignum-vitæ, put in so as to wear on end of grain, and smoothly and accurately bored in place to suit the shaft casing. All the lignum-vitæ bearings will be well water-soaked, and bored out in place to perfect alignment and to a loose fit on the shaft casing.

59. STERN TUBE STUFFING BOXES.

At the forward end of each stern tube there will be a composition stuffing box, made in halves, divided longitudinally. It will be bolted to the flange on the forward end of the stern tube bushing. The two parts will be bolted together along the longitudinal division by proper flanges. The follower will be of composition, in two parts, with a space of 1¼ inches between the parts on each side. The packing spaces will be about 7 inches deep and 1 inch wide.

The follower bolts will be of rolled manganese or Tobin bronze. To each stuffing box, abaft the packing, a 1-inch pipe will be attached leading to the engine room bilge. It will also be connected with the engine room water service pipes, and will be provided with a valve, so that the bearing can be drained into the bilge or washed out by water from the engine room pump at will.

60. STERN BRACKET BEARINGS.

Each stern bracket bearing will have a neatly fitting composition lining, made in halves, divided longitudinally. It will have a lignum-vitæ bearing, fitted as in the stern tube. The lignum-vitæ will be held in place at

the forward end by a flat ring bolted to the lining. A cast steel sleeve, ½ inch thick, will be secured to each stern bracket by four ¾-inch screws, to form a fair water line to the propeller boss. At the forward end of each bearing there will be a composition sleeve, ⅜ inch thick, secured to stern bracket boss. This sleeve will be shaped to form a fair water line from the shaft to the stern bracket boss, and will be finished on the outside.

61. SCREW PROPELLERS.

They will be of manganese bronze or approved equivalent metal. The starboard propeller will be right and the port one left handed. Each blade will be firmly bolted to the boss by tap bolts of rolled manganese or Tobin bronze, secured by lock plates. The recesses for the bolt heads will be covered by composition plates held by countersunk screws, and finished to form a smooth surface fair with the boss. The bolt holes in the flanges of the propeller blades will be made oval to allow of adjustment of the pitch.

Each boss will be accurately bored to fit the taper on after end of shaft and fitted with a feather key. Each propeller will be held on the shaft by a nut screwed on and locked in place. The shaft casing will enter about 1 inch into the propeller boss and be fitted water-tight. Each boss will be finished at the after end by a composition cap bolted on water-tight; the bosses and caps will be finished all over. The blades will be cast as smoothly as possible and have any roughness removed, and when finished must all be of equal weight. The flanges of the blades will be turned and faced to fit the recesses in the bosses accurately, and, after being secured in place, must have the edges made fair.

62. CONDENSERS.

There will be two cylindrical condensers, each 3 feet internal diameter, cast of composition not over ⅜ inch thick. The shell will be in two parts as shown.

There will be the following openings in each condenser, each with properly faced flanges, viz.:

One for main exhaust pipe, 12 inches diameter; one for

auxiliary exhaust pipe, 6 inches diameter; one for air pump suction pipe, 6 inches diameter; one 6-inch hand hole, with nozzle for salt feed spray and soda cock in the cover; one-6 inch hand hole, with 1½-inch nozzle for boiling out, as shown. The condensers will be supported from the feed tanks, as shown.

The tube sheets will be made of composition, ⅞ inch thick, with smoothly finished holes for the tubes, tapped and fitted with screw glands for packing the tubes. There will be a hand hole at the lower part of each tube sheet. The glands will be beaded at outer ends to prevent tubes from crawling, and will be slotted to admit a tool for screwing up. Cotton-tape packing will be used. Each condenser will contain 946 seamless drawn brass tubes, ⅝ inch outside diameter, No. 18, B. W. G. in thickness; they will be 8 feet long between tube sheets and will be spaced $\frac{15}{16}$ inch between centers. The cooling surface of each condenser will be about 1,238 square feet, measured on the outside of the tubes.

The two sections of condenser-shell will have flanges for securing to each other and to connect with the tube sheets. The tube sheets will be secured to the flanges of the shell by naval brass or Tobin bronze collar bolts, which will also be used for fastening the circulating water chests.

The chest for entrance and exit of circulating water will be made of composition, with a division plate in the middle and with two hand holes. It will have a lifting lug cast on and be provided with an air cock and a drain cock, as shown. The inlet and outlet nozzles will each be 6 inches in diameter of opening.

The water chest at the other end will be cast as shown. It will have one manhole.

The nozzle for connecting the condenser with the auxiliary exhaust pipe will be of composition, and will be reduced from the size of opening to that of the pipe.

Baffle plates of brass will be fitted, as shown, to direct the steam over all the tubes. Plates will be provided for supporting the tubes and to act also as baffle plate. In

front of the main exhaust nozzle, above the tubes, will be a deflecting plate, supported as shown.

A copper tank, pipe, and a cock will be provided for admitting an alkaline solution into each condenser—this pipe to connect with the salt-fed spray; the tank to be of at least 5 gallons capacity and conveniently placed. A 1-inch branch from the auxilary steam pipe will lead to the bottom of the condenser for cleaning the tubes by boiling. Drain cocks will be provided with pipes leading to the bilge, and all cocks to have suitable handles for working them.

All parts of the condenser, except as otherwise specified, will be made of composition. All bolts to be of naval brass or Tobin bronze. All bolts for securing flanges of pipes and manhole plates will be standing bolts, and will, wherever possible, be screwed into the condenser plates, with heads inside. The condenser must be perfectly tight all over and be so proved after being secured in place.

63. AIR PUMPS.

There will be for each condenser one vertical single-acting air pump, 14¾ inches diameter, worked from the second intermediate-pressure crosshead.

The channel-way, barrel, bucket, top, and valve seats will be cast of composition, as shown. The rod will be of rolled manganese, phosphor, or Tobin bronze, and will be guided by composition brackets supported from the top of the pump. It will be 1⅞ inches in diameter, tapered through the bucket and the crosshead to 1⅜ inches, and reduced to 1 inch through the guide.

The channel-way will be cast with two palms for bolting to the face of the bed-plate, and be faced on the bottom for bolting to the top of bed-plate. It will be enlarged, as shown, with a flange for bolting the suction pipe to. All bolts will be through bolts of rolled manganese or Tobin bronze.

The barrel will be bored to a diameter of 14¾ inches, leaving the metal $\frac{7}{16}$-inch thick. The upper part will be enlarged to an internal diameter of 18¾ inches, and will

form a seating for the delivery valve seat. It will have facings for bolting two composition stays from the engine columns, a flange for bolting to the top, and a nozzle for the discharge pipe, as shown.

The top will be 18⅜ inches inside diameter, and will have raised facings on its upper surface for supporting the guide brackets and the beam rock shaft bearings.

The suction valve seats will be bolted to the pump barrel and channel-way, as shown, the joints between them being scraped surfaces. The delivery valve seat will rest on the top of the barrel and be held in place from the top of the pump by a spiral spring of phosphor bronze, which will allow the seat to lift when the pressure beneath it exceeds 3 pounds per square inch.

The bucket will be cast as shown; will have a wearing surface 3 inches wide and be grooved for water packing. It will have a stroke of 6 inches. The upper surface will be a grating, as shown, fitted for six valves 3¾ inches diameter. The valves will be composed of three flat disks of rolled manganese bronze or approved equivalent metal $\frac{1}{32}$ inch thick, and will be held in place by a guard and spiral spring of phosphor bronze or approved equivalent metal. The valve studs will be of similar material. The valves and guards must be easily removable and held firmly in place. The valve gratings must be so arranged as to give a clear opening of 7 square inches through each valve.

All flanges will be tapped for and provided with jack bolts and eyebolts.

A suction pipe, 6 inches in diameter, will connect the channelway with the condenser, and a delivery pipe 5 inches in diameter, the delivery chamber with the feed tank. A straightway valve will be placed in the suction pipe near each pump, so that the pump may be shut off when the condenser is used for auxiliary purposes.

This pipe will have a branch to the auxiliary air pump 2¾ inches in diameter, with a straightway valve in it. The delivery pipe will have a 2½-inch branch brazed on for the auxiliary air pump discharge.

Each air pump, together with its condenser, must

maintain a vacuum within four inches of mercury of the atmospheric barometer with the propelling engines at full power under forced draft.

The air pump crossheads will be of steel, as shown, with journals at each end 2 inches in diameter, and will be connected to the beam pins by links 6 inches long, as shown. The hole in the central boss will be tapered for the air pump rod from 1⅝ inches diameter at the bottom to 1⅜ inches at the top.

The rock-shaft bearings will be of cast iron, with composition boxes, and will each be secured to the top of the pump by six ⅝-inch bolts of rolled manganese or Tobin bronze. The bearings will be 3 inches in diameter and 3 inches long.

The rock shaft will be of steel, 3 inches in diameter, with an axial hole 1½ inches in diameter. It will be enlarged outside of bearings to a diameter of 3½ inches for attachment of the beam plates.

The beams will be of plate steel, $\frac{5}{16}$ inch thick, each pair for each engine being double and the plates of each pair separated a distance of 1¾ inches. The pins at ends of the beams will be 2 inches in diameter at air pump end, and 1⅝ inches at crosshead end, and will be secured to beams as shown.

The plates will be 3½ inches wide at crosshead end, 4½ inches at pump end, and will be enlarged to a diameter of 7½ inches at rock shaft, to which they will be keyed, the plates being held apart by thimbles riveted to them.

64. AUXILIARY AIR PUMP.

There will be an air pump 6 inches in diameter, run from the crosshead of each circulating engine, as shown on drawing. It will have a stroke of 4 inches, and will be similar in design and general construction to the main air pumps, except that the beam rock-shaft will be supported from the engine frames, and that the links will be flat bars, bushed. The suction pipes will be 2¾ inches and the delivery pipes 2½ inches in diameter. The delivery pipes will discharge into the delivery pipe for

main air pump at a point such that the water will run only into the feed tank. The suction pipes will each have a branch for discharge from the evaporator trap.

65. CIRCULATING PUMPS.

There will be one centrifugal double-inlet circulating pump for each condenser, driven by independent engines of approved pattern, and of sufficient power to secure the results specified. The engine valves will be of either the slide or piston type. Each pump must be capable of discharging 2,500 gallons of water per minute from the bilge. The pumps will be made of composition, except as otherwise specified. Each pump casing will be made as shown in two parts, ~~divided in a horizontal plane, the upper part with conveniences for handling.~~ The suction nozzle will have an opening for sea suction not less than 7 inches diameter, and a 7-inch opening for bilge suction. The delivery nozzle will have a branch cast on for connecting the water service supply pipe. The pump runners will be smoothly cored, finished on the outside, and perfectly balanced. The shafts will be of phosphor bronze or other approved metal. The bearings will consist of sections of lignum-vitæ, on end of grain, dovetailed into composition split sleeves, which will be well secured against turning. ~~The stuffing-box glands will be each in two parts.~~ There will be an air cock at the top of the pump casing and a drain cock at the bottom. The pump casings must be made as light as possible consistent with strength, and must be smoothly cored, with easy bends wherever the direction of the flow of water is changed. The circulating pumps will take steam from the auxiliary steam pipe.

The crosshead will work the auxiliary air pump by means of links and a beam in the same manner as the main air pumps are worked from the main engines.

66. CIRCULATING PUMP CONNECTIONS.

Each circulating pump will be fitted with pipes and valves to draw from the sea, from the double bottom, from the main drain, and from the engine room bilge, and will deliver into the condenser or direct to the outboard

delivery pipe by a pipe connecting inlet and outlet of condenser. This pipe and the inlet pipe each to have a straightway valve, and the outlet pipe a butterfly valve.

The injection and delivery pipes for condenser circulation will be not less than 7 and 6 inches internal diameter respectively.

There will be stop valves in the pipes leading from the sea and from the bilge to the circulating pumps. These valves will be so connected by a locking device that when one is open the other is shut; and both will be worked by hand wheels well above the floor plates.

67. SEA INJECTION VALVES.

There will be one screw main injection valve 7 inches diameter for each condenser. Each will be on the same side of the ship as its condenser, and will connect with the sea by a conical steel tube passing through the double bottom.

There will be a strainer on each pipe at the ship's side. The hand wheels of these valves must be easily accessible above the engine room floor plates.

There will be a 1-inch steam pipe leading from the auxiliary steam pipe to the injection pipe outside of injection valve. This pipe to have a valve at each end.

68. BILGE INJECTION VALVES.

They will be as specified under the head of "Bilge suction Pipes."

69. OUTBOARD DELIVERY VALVES.

There will be one straightway main outboard delivery valve 6 inches diameter for each condenser.

It will be secured to the water-tank bulkhead, and connect with a steel tube $\frac{5}{8}$-inch thick, riveted to the side of the ship and to the tank bulkhead.

70. FEED TANKS AND FILTER.

There will be a feed tank for each engine, placed as shown in the drawing. Each tank will have a capacity of about 200 gallons. It will be made of $\frac{3}{16}$-inch wrought iron. It will be braced internally as may be directed.

Each tank will have at least 30 cubic inches of rolled zinc plates, about ½ inch thick, suspended from the braces. The straps suspending the zinc plates and the braces where the straps come in contact will be filed bright before being secured in position. The parts to be then well painted on the outside, or the joints to be made water-tight in other approved manner. A portion of the tank will be fitted as a filter so that the entering water will rise through the filtering material into which the water from the air pumps will be delivered. The filter will be provided with sponges, or other approved material, and so arranged that it will be readily accessible. Each tank will have a manhole with bolted cover, and will have a glass water gauge with suitable guards, shut-off cocks, and drain cocks, and will be fitted and lagged with black walnut lagging.

Each tank and filter will have the following pipe connections: A discharge pipe from its own air pump; an overflow pipe leading to bilge, but so arranged that any water passing down it may be seen; a suction pipe to feed pumps, with valve; drain pipes from traps, as elsewhere specified; a vapor pipe, 1½ inches diameter, of copper, No. 16 B. W. G. The vapor pipes will lead up the engine room hatches and discharge above the level of the awnings, where they will have suitable hoods, or they may be led into the main escape pipe. Each feed pump suction will be provided with a balanced valve operated by a copper float in the feed tank, so arranged that it will allow no air to enter the feed pipes. All trap discharges and drains will enter the feed tanks well below the ordinary water level.

71. GREASE EXTRACTORS.

If ordered, grease extractors, to be approved by the Bureau of Steam Engineering, will be fitted where directed.

72. FEED TANK SUCTION PIPES.

Both feed tanks will be connected by a pipe from which branches shall be led to the main and to the auxiliary feed pumps. Straightway valves will be fitted in this

pipe at the tanks, and non-return valves in the branches close to the pumps.

73. SEA SUCTION PIPES.

A pipe will lead from a sea-suction valve in the engine room to the fire and bilge pump, and to the water-service pump, and from a sea valve in each fire room to the auxiliary feed pump in that fire room, to the bottom blow valves, and to the pump discharge manifold. Each of these pipes will be of at least the same bore as the nozzle on the pump with which it connects. Each sea suction will be controlled by a valve which will not permit sea water to enter any of the bilge-suction pipes or feed-tank suction pipes. Each sea suction valve, except those for fire room pumps, will have a steam pipe connection below the valve for cleaning strainer.

74. BILGE SUCTION PIPES.

There will be the following suction pipes from the bilge and from the drainage pipes to the various pumps:

A 7-inch copper pipe will connect to each circulating pump, with a non-return screw stop valve close to the pump, as before specified. This pipe will have ~~three~~ two galvanized wrought-iron branches 5 inches in diameter, one of which will connect with the main drain pipe, ~~another with the engine room bilge~~, and the ~~third~~ other with the double bottom. The branches to the bilge and to the double bottom will each be fitted with a screw down non-return valve which can be lifted from its seat by means of a sliding stem. The branch to the bilge will be fitted with a Macomb strainer of approved size which can be readily removed from the engine room floor.

A copper pipe of the size of the suction nozzle of the fire and bilge pump will connect that pump with the main drain pipe. It will have a branch 2 inches in diameter, with plug cock in it, leading directly to the engine room bilge, and be fitted with a Macomb strainer, and a screw down non-return valve close to pump. The handle of cock in branch will be worked from the engine room floor.

Each auxiliary feed pump in the fire rooms will have a suction pipe the size of its suction nozzle connecting with the main drain, and one 2 inches in diameter leading to the bilge of its own compartment, with a Macomb strainer and a screw down non-return valve near the pump; the latter pipe may be a branch of the former, fitted like the engine room suction pipe.

There will be no strainer or valves in any of these pipes other than those herein specified.

The lower ends of all bilge suction pipes will be of galvanized iron. Care will be taken that all the copper bilge pipes are led sufficiently high to keep them out of the bilge water under ordinary circumstances.

75. MAIN AND AUXILIARY FEED PUMPS.

There will be two main feed pumps in the engine room, each capable of delivering 65 gallons per minute; an auxiliary pump of the same size in the after fire room, and one of 150 gallons in the forward fire room—all to work against a pressure of 250 pounds.

The capacity of the 65-gallon pumps will be calculated on 100 feet per minute piston speed, and 75 per cent efficiency; and that of the 150-gallon pump at 100 feet piston speed and 100 per cent efficiency.

In the above pumps the water valves will be metallic of approved kind. The pumps will be so arranged that the packing of the water cylinders will he easily accessible. The steam cylinder must be of sufficient size to work the pump at the required speed to supply the water above required.

The exhaust cushion must be adjustable. The water cylinders, pistons, and pumps, and pump rods will be of composition or bronze, and all other working parts will be of wrought iron or steel. The water cylinders will have a removable lining for convenience in reboring.

Each main feed pump will draw water from the feed tanks and from the fresh water tanks, and deliver into the main feed pipe and fresh water tanks, the delivery

pipe into tanks being a branch of the feed pipe with a valve in it.

Each auxiliary feed pump will be arranged to draw from the main feed tanks, the sea, the bilge, the air ducts, or the boilers, at will, and to discharge into the boilers through the feed valves, into the fire main, or overboard through the sea valve of its own compartment. Auxiliary pumps will have steam cylinders sufficiently large to work as fire pumps with steam of 80 pounds pressure.

The pumps may be either horizontal or vertical, but revolving crank pumps will not be allowed.

76. ENGINE ROOM PUMPS.

There will be in the engine room a pump capable of discharging 150 gallons per minute, which will be fitted as a fire and bilge pump. It will have suctions from the sea and from the bilge, and will deliver into the fire main, and overboard through a special pipe and valve placed where directed.

There will also be in the engine room a pump of 100 gallons capacity which will discharge into the fire main, into the water service pipe, and around the coils of the fresh water distillers. The connection with the fire main may be a by-pass from the distiller pipe if desired. This pump will draw water from the sea only.

A special sea valve will be fitted for these pumps.

77. PUMP CYLINDERS.

All pump cylinders, together with their valve boxes and fittings, will be made of composition, and the cylinders over 6 inches diameter will be fitted with working linings for convenience in reboring, unless otherwise specified. Air chambers will be fitted on the delivery sides of pumps or in the pipes, as may be directed.

The water cylinders of all vertical pumps will be so arranged that the pistons are easily accessible and fitted for overhauling without disturbing the framing or piping. All pumps will have either packed pistons or packed plungers, excepting air pumps, which will be made as shown.

78. PUMP RELIEF VALVES.

All feed and fire pumps will have adjustable spring relief valves of approved design, connecting the delivery and suction passages.

79. ENGINE ROOM WATER SERVICE.

There will be in each engine room for each engine a 2-inch pipe connected with the delivery nozzle of the circulating pumps and with a special delivery from the auxiliary pump, with branches leading to the different parts of its engine, as follows :

Two ¾-inch pipes to each crank pin.

Two ½-inch pipes to each crosshead.

One ¾-inch pipe to each go-ahead crosshead guide.

One ¾-inch pipe to each pair of eccentrics.

One 1-inch pipe to each thrust bearing.

One ¾-inch pipe to each line shaft bearing.

One ¾-inch pipe to each hollow brass or its equivalent in crank-shaft bearings.

One ¾-inch pipe to each circulating pump engine.

All of the above to have detachable sprays or short lengths of hose, as directed, and where directed to have pivoted nozzles. The water service pumps will have a connection to stern tubes as before specified.

Each branch will have a separate valve.

All the water service pipes and fittings will be of brass; those above the floors will be polished.

80. FRESH WATER TANKS.

The fresh water tanks, built into the ship, will be connected with the main feed pumps, as elsewhere specified, and will each be provided with two glass water gauges, each about 3 feet long and well protected, and an air cock, and will have a connection for filling them. They will have suitable manholes, with plates, so that they can be thoroughly cleaned.

81. TURNING GEAR.

There will be approved gear fitted to each engine for turning it by hand.

It will comprise a cast-steel or composition wheel, with cut teeth, on each shaft, meshing with a worm operated by a ratchet wrench, the arrangement being such that the gear can be readily connected and readily thrown out.

82. SECURING ENGINES IN VESSEL.

The engines will be adjusted and aligned upon the engine keelsons, and when accurately in line snugly fitting wrought-iron washers or horse shoes will be fitted around all holding-down bolts. The holding-down bolts will be firmly set up and bolts and nuts locked in place.

When finally secured all shafting must be accurately in line with the vessel at load draft and ordinary stowage.

All parts of machinery and boilers will be secured in an approved manner to prevent displacement when the vessel is used for ramming.

83. STEAM AND VACUUM GAUGES.

There will be the following gauges, in polished brass cases, suitably engraved to show to what they are connected—all to be of approved pattern, having seamless double Bourdon tubes:

One on each boiler.

One connected to each main steam pipe in engine room.

One connected to each intermediate-valve chest.

One connected to each low-pressure valve chest.

One connected to each condenser.

All the above will have 8½-inch dials—those in engine room to be at the working platforms.

Also the following, with 4½-inch dials:

One connected to each intermediate-pressure cylinder jacket.

One connected to each low-pressure cylinder jacket.

One on auxiliary steam pipe in engine room, and one in each fire room.

One on each circuit of radiator pipes near the reducing valve.

One on steam pipe to galley near the reducing valve.

The gauges on valve chests and steam jackets will be plainly marked with the limit of pressure permissible. The gauges on intermediate and low-pressure valve chests will indicate both pressure and vacuum.

A mercurial vacuum gauge will be connected to each condenser.

84. THERMOMETERS.

There will be the following thermometers, all to be permanent fixtures, protected by brass covers, the casings and fittings to be of polished brass:

One on each hot well.

One on each main feed pipe in fire room.

One on each main injection pipe.

One on each main outboard delivery pipe.

One on each main steam pipe close to engine.

The hot well and feed thermometers will be so fitted as to waste no feed water. With the exception of that on the steam pipe, the above instruments will be metallic dial thermometers. There will also be furnished—

Four spare water thermometers complete.

Six spare steam thermometers complete.

Two standardized thermometers, graduated on stem and reading to $\frac{1}{5}$ degree Farenheit, one from 32 to 130 degrees, the other from 120 to 215; stems to be at least 20 inches long; each thermometer to be in a rubber-lined brass case, and each case to be suspended by springs in a suitable permanent locked case in engine room. These thermometers must be equal to the best in the market, subject to the approval of the Bureau of Steam Engineering, and be accompanied by certificates of standardization.

85. REVOLUTION COUNTERS.

They will be of the continuous rotary type, to register from 1 to 1,000,000, each worked by positive motion; each to be in a polished brass case. There will be fitted—

One for each main engine.

One for each circulating pump.
Reciprocating motions will not be permitted.

86. REVOLUTION INDICATORS.

A revolution indicator will be fitted in the engine room, and so placed as to be readily seen from the working platform. It will be worked from the engines by positive motions, and be so constructed that the relative speed of both engines may be seen on the same dial at a glance. The dial will be graduated to 100 revolutions, each graduation indicating one revolution of the engines. Provision will be made for stopping either pointer so that the engines may be quickly regulated with the aid of the indicator.

Approved tell tales, to be approved by the Bureau of Steam Engineering, will be fitted on the bridge to show the direction of the revolution of the main engines.

87. ENGINE ROOM TELEGRAPHS.

A repeating telegraph of approved pattern will be fitted for each engine with its dial at the working platform, and connected to transmitters in wheelhouse and on bridge. They shall be so placed that the handles point forward for the ahead motion. The connections are to be made in such manner that the chance of derangement shall be minimized.

88. SPEAKING TUBES.

They will be made of copper or brass not less than No. 20 B. W. G. They will connect the engine room with each fire room; the fire rooms with each other; the engine room to the ~~pilot house, bridge, and to the~~ chief engineer's room; each fire room with the upper deck close to the top of the ash hoist, and elsewhere as required. Each tube will be fitted at each end with a mouth-piece and approved annunciator; the mouth-pieces to be connected to short flexible pipes, where required. All mouth-pieces or pipes will be plainly marked. The tubes will be suitably cased where necessary.

89. ENGINE INDICATORS.

An indicator connection will be made to the end of each cylinder of main engines, and to the end of water cylinder of each air pump as near as possible to the bore of the cylinder, and so as to be easily accessible. The indicator cocks will be so fitted on each cylinder of the main engines that the indicators may be so placed as to be connected to both ends of the cylinder; the arrangement to be approved by the Bureau of Steam Engineering.

The connecting pipes will be 1-inch bore for the main engines and ¾-inch for the auxiliaries, with easy bends. The motions of the indicator barrels must be accurately coincident with the motion of the corresponding pistons, and such as to give a motion of not less than 3 inches. The steam cylinders of all auxiliary engines will have holes tapped for indicator fittings and then plugged. These engines will have portable indicator motions fitted, then removed and suitably marked and stowed. Where auxiliary engines are duplicated, but one set of indicator-motion fittings need be supplied for all of each kind.

Four indicators will be furnished for each engine: one for each high-pressure cylinder with two springs of 150 pounds to the inch; one for each first intermediate-pressure cylinder, with two springs of 100 pounds, one of 80 pounds, and one of 60 pounds to the inch; one for each second intermediate-pressure cylinder, with two springs of 40 pounds and two of 30 pounds to the inch; one for each low-pressure cylinder, with two springs of 20 pounds and two of 10 pounds to the inch; and one indicator for auxiliary engines, with two springs of 80 pounds, one of 60, and one of 40 pounds to the inch.

The indicators will be the best in the market, all of the same manufacture and size, and with interchangeable springs, subject to the approval of the Bureau of Steam Engineering, with detent motion, and will have adjustable tension to the barrel spring. They will be nickel-plated, and will be complete with all attachments. One

extra cock attachment will be furnished with each indicator. Each indicator will be in a separate locked case, with engraved plate, each case to be conveniently stowed.

90 ENGINE ROOM DESK.

A black walnut desk of approved pattern, with locked drawers, and with a locked cabinet of pigeon holes, will be fitted in the engine room where directed.

91. CLOCKS.

There will be in the engine room, close to the counter, in a polished brass case, an eight-day clock, with 8½-inch dial and a second hand. The pattern and movement to be approved by the Bureau of Steam Engineering.

There will be in the forward fire room a similar clock, with an outer dust-tight case with heavy plate glass.

92. BOILERS.

There will be four main boilers of the tubulous type, constructed for a working pressure of 250 pounds per square inch, and two auxiliary boilers of the horizontal fire tubular type, constructed for a working pressure of 160 pounds per square inch.

The boilers will be placed in two separate compartments, as shown on the drawings, the auxiliary boilers being in the compartment nearest the engine room.

The main boilers shown on the Department's plans, four in number, each contain about 25 square feet of grate suaface, and about 1,900 square feet of heating surface. Any other type of coil, sectional, or tubulous boiler may be put in subject to the approval of the Bureau of Steam Engineering, provided it does not exceed in weight the amount allowed for these boilers, that an equal number of boilers be put in, and that the facilities for cleaning and repairing be satisfactory.

The auxiliary boilers will be about 7 feet 8 inches outside diameter, and about 9 feet 11 inches long, and will each have about 675 square feet of heating, and about 21

square feet of grate surface. Each will have one corrugated furnace flue 40 inches internal diameter.

93. BOILER MATERIAL.

All plates used in the construction of the boilers will be open-hearth steel. The rivets will be of open-hearth or Clapp-Griffith steel. All material will be tested, as elsewhere specified.

94. BOILER SHELLS.

For the auxiliary boilers, they will be made of $\frac{11}{16}$-inch plates, the shell of each boiler in two rings, and each ring of one plate.

The drums of tubulous boilers will be of approved thickness.

95. BOILER HEADS.

Each head of each auxiliary boiler will be made of two plates—the upper one $\frac{11}{16}$ inch and the lower one $\frac{5}{8}$-inch thick, the latter also forming the front tube sheet.

The upper plate of each head will be curved back to a radius of about 16$\frac{5}{8}$ inches.

The heads will be flanged outwardly at the furnaces and inwardly at the circumference, and will be stiffened by angle bars, as shown on drawings.

96. BOILER TUBE SHEETS.

They will be $\frac{5}{8}$ inch thick, and be braced as shown. Each pair of tube sheets must be accurately parallel. All tube holes will be slightly rounded at the edges. The holes for stay tubes will be tapped in place, and those at combustion chamber end will be drilled to suit the protection of tubes, as specified below.

97. BOILER TUBES.

For the auxiliary boilers they will be of charcoal iron, lap-welded and drawn, the best that can be obtained in the market, and subject to the approval of, and the tests prescribed by, the Bureau of Steam Engineering. All tubes will be 2$\frac{1}{4}$ inches external diameter. The ordinary tubes will be No. 10 B. W. G. in thickness, and will be swelled to 2$\frac{5}{16}$ inches external diameter at the front

ends. The back ends will be expanded in the tube sheet, beaded over into a counter bore, which will be filled with a ring, or they will be protected from the action of the flame in other approved manner. The method of protection must be such as will meet with the approval of the Navy Department.

The stay tubes will be No. 6 B. W G. in thickness. They will be reinforced at both ends to an external diameter of 2⅜ inches, leaving the bore of the tube uniform from end to end. They will then be swelled at the front ends to 2½ inches external diameter. They will be threaded parallel at combustion chamber ends, and taper at front ends to fit threads in tube sheets. They will be screwed into the tube sheets to a tight joint at the front ends, and will be made tight at the back ends by expanding and beading. All expanding will be done by approved tools. Cast iron ferrules of 1½ inches internal diameter will be used to protect the ends of stay tubes in combustion chambers. All tubes will be spaced 3¼ inches from center to center vertically, and from 3¼ to 3¾ inches horizontally, disposed as shown on the drawing. If directed, the tubes shall be finished according to designs furnished by the Navy Department.

The material, size, thickness, and spacing of tubes for the main boilers will be subject to the approval of the Bureau of Steam Engineering.

98. COMBUSTION CHAMBERS.

There will be one combustion chamber for each auxiliary boiler. They will be made of ½-inch plates, except the tube sheets, which will be as before specified. The tops of the combustion chambers will be rounded to a radius of about 18½ inches as shown. The plates will be flanged where necessary, and all parts joined by single riveting. The holes for screw stay bolts in plates of combustion chambers and shells will be drilled and tapped together in place.

99. BOILER BRACING.

The bracing of the auxiliary boilers will be as shown in drawings.

The combustion chambers will be stayed to the shell of the boiler by screw stays, screwed into both sheets and fitted with nuts—the nuts to be set up on beveled washers where stays do not come square with the plates. The holes for screw stays will be tapped in both sheets in place.

The tops of combustion chambers will be braced to the back heads by gusset plates and heel braces as shown on the drawing. The gusset plates will be secured to the tops of combustion chambers by socket rivets, as shown.

There will be six 1⅞-inch longitudinal braces, spaced 12 inches apart, except the center ones which will be 13 inches, secured by nuts on the inside and outside of the heads. The lower front heads will be braced as shown by two braces to the back tube sheet, and by two palm braces to the shell, all 1$\frac{11}{16}$ inches thick, and as shown on the drawing.

The bottom of the combustion chambers will be stiffened by angles.

All screw stays and all screwed braces will have raised threads.

All braces will be made without welds.

In boiler braces fitted with eyes, care must be taken that the sectional area through the neck or eye is not less than that of the cylindrical portion.

The bracing of coil, sectional, or tubulous boilers must meet the approval of the Bureau of Steam Engineering.

100. RIVETED JOINTS.

The longitudinal joints of boiler shells will be butted, with ⅝-inch straps outside and $\frac{9}{16}$-inch inside, and treble riveted, as shown on the drawings. Joints of heads with shells will be double riveted; all other circumferential joints will be lapped and treble riveted. Joints in furnaces and combustion chambers will be single riveted. Rivets will be of Clapp-Griffith steel, with heads in accordance with Bureau of Steam Engineering standard. Edges of all plates in cylindrical shells, and of all flat plates where not flanged, will be planed. Edges of flanges will be faired by chipping or otherwise, as may

be approved. Plates in cylindrical shells must not be sheared nearer the finished edge than one-half the thickness of the plate along the circumferential seams, and not nearer than one thickness along the longitudinal seams. No plate must average less than the specified thickness along the longitudinal seams. All rivet holes in shell plates will be drilled in place after bending. Hydraulic riveting will be used wherever possible. In parts where dydraulic riveting can not be used, the rivet holes will be coned and conical rivets used. Seams will be calked on both sides in an approved manner. Longitudinal seams will break joints. All joints will be as shown on drawings.

101. BOILER MANHOLES AND HANDHOLES.

There will be manholes in each auxiliary boiler, placed, and of such size, as shown in drawing.

All manholes will have stiffening rings. The upper manhole will have a raised cast-steel frame flanged and riveted to the inside of the shell of the boiler, as shown.

The manhole plates will be of mild steel and stamped in dished form. All manhole plates will be secured by two wrought-iron dogs and two 1¼-inch studs with square nuts. Each plate will have convenient handles.

There will be a handhole in the back head of each boiler as shown, with plate secured similarly to manhole plates.

All plates, dogs, and nuts will be indelibly marked to show to what holes they belong.

Manhole and handhole plates in tubulous boilers will be placed where directed.

102. FURNACES.

Each corrugated furnace flue will be in one piece, $\frac{9}{16}$ inch thick, 3 feet 4 inches least internal diameter and 3 feet 8 inches greatest external diameter. They must be perfectly circular in cross section at all points. They will be riveted to flanges of front heads, and will be flanged and riveted to combustion chamber plates.

103. GRATE BARS AND BEARERS.

The grate bars for all boilers will be of wrought iron or of approved shaking pattern as directed. They will be so fitted that they can be readily worked under forced draft without opening the furnace or ash pit doors, and without allowing an escape of air or gases. They will also be so fitted as to be readily removed and replaced without hauling fires. The bars at sides of furnaces will be made of cast iron to fit the corrugations. The bearers will be made of wrought iron, supported by wrought-iron lugs bolted to the furnace flues, and perforated so as to allow the air to reach all parts of the grate bars.

104. BRIDGE WALLS.

They will be made of cast iron, so fitted as to be readily removable. They will extend back to the back of combustion chambers so as to leave no place behind them where dirt can accumulate. They will be finished with fire brick or other approved refractory material.

105. FURNACE FRONTS.

For all boilers they will be made with double walls of wrought iron, bolted to a light frame. The space between the two walls will be in communication with the ash pits. The upper part of the inner plate of furnace fronts will be perforated as directed. The dead plates will be made of cast iron, and fitted so as to be easily removed and replaced. The door openings will be as large as practicable. There will be a beading on the inside of the door frame in wake of the inner plate of door to make the clearance as small as possible.

106. FURNACE DOORS.

The furnace doors for all boilers must be protected in an approved manner from the heat of the fire. There will be three hinges to each door, all of wrought iron; the upper hinge will be so made as to support the weight of the free end of the door, and so fitted that the sag can be easily taken up. The latches will be of wrought iron.

Each furnace door will be fitted with an approved slicing door. Drawings showing the arrangement of furnace fronts and furnace doors must be submitted to the Bureau of Steam Engineering before work is commenced on them.

107. AIR DUCTS.

The fire room blowers will take air from the fire room and discharge into ducts leading to the ash pits.

The ducts will be constructed of iron or steel plates not less than $\frac{3}{16}$ inch thick, the bottom of the portion under fire room floors being formed by the inner skin of the vessel, and the top by the fire room floor plates, which must be so secured as to make a water-tight joint over the duct, and to be easily removed for painting the inner bottom. At the center, for a width of 12 inches, the bottom of the duct will be formed by a plate 2 inches above the inner bottom, so as to permit a flow of water beneath the duct.

From the main air duct branches will lead to all ash pits; each will be fitted with a damper at the mouth of the ash pit, and be provided with lever and catch for opening and closing, the lever to be so connected with the furnace door latch that that door can not be opened without closing the damper.

A 2-inch suction will lead from the lowest part of each main duct to the auxiliary pump in the same fire room.

108. ASH PIT DOORS.

They will be made of $\frac{1}{8}$-inch wrought iron, stiffened with angle or channel iron, and be fitted with asbestos or other approved material to make an air-tight joint when fastened to air ducts; this packing to be so fitted as to be protected from injury, and so as to be readily renewed. Each door will be fastened by wrought-iron buttons bolted to lugs on the walls of the air duct, each button setting up on a wedge riveted to the door.

Each door will be the full size of the ash pit, and will have no connection with the air ducts except by means

of the joint above specified; each will have two wrought-iron handles for lifting, and two wrought-iron beckets to fit hooks on uptake doors.

109. LAZY BARS.

A portable lazy bar with the necessary lugs will be fitted in the front of each ash pit, also portable lazy bars for the furnaces.

110. ASH PANS.

Ash pans of ¼-inch wrought iron, reaching from the front of furnace to bridge wall, will be fitted to all furnaces.

111. CIRCULATING PLATES.

Each cylindrical boiler will have circulating plates fitted at each side of each nest of tubes. They will be of steel, ⅛ inch thick, in sections, so as to be easily introduced and removed through manholes. Each section will have two clips at upper and one at lower end for supporting it from the stay tubes. The plates will be well painted all over with two coats of approved paint or cement.

112. UPTAKES.

For the auxiliary they will be of three thicknesses, of wrought iron or steel, double spaced, built on angle, channel, or **Z** bars, and be bolted to the boiler heads and shells. The inside sheet will be No. 8 B. W. G., and will be bolted to the lower part of the smoke pipe, having oval holes to allow for expansion.

The space between the two sheets will be two inches, open at the bottom, and will be in communication with the space between the smoke pipe and its casing.

Outside the double uptake there will be a sheet of No. 12 B. W. G., iron or steel, making in all three thicknesses of iron or steel. This latter sheet will have a space of 2 inches between it and the middle sheet, and will extend to the height shown on the drawings. This 2-inch space will be filled with magnesia or an approved non-conducting substance.

For the main boilers the uptakes will be in two thicknesses, and as shown on the drawing.

The uptakes for all boilers will be supported between the protective and the gun deck as shown.

113. UPTAKE DOORS.

The uptake doors will be made in a similar manner to the uptakes as before described, but in addition they will be fitted with a "baffle" plate of No. 10 B. W. G., stayed 2 inches from the inner sheet of the door.

The hinges and latches will be made of cast or wrought steel or wrought iron. The doors must be hung so that they will swing out in line with the tubes without interference. Each door will have two hooks for hanging the ash pit doors on, and a hook for a tricing rope.

114. SMOKEPIPES.

There will be two smokepipes, each about 80 feet in height above the grates. The pipe for the main boilers will be 5 feet internal diameter, and that for the auxiliary boilers 3 feet, both finished to an outside diameter of 5 feet 6 inches.

The pipe for the main boilers will come through the gun deck in two parts, each part connecting with the uptake. These parts will join into a round section at the gun deck. The weight of the pipe will be taken on the gun deck, the parts of the pipe passing through this deck being of ¼-inch plate, spaced about 2⅜ inches apart, and secured to each other by channel or Z bars. The outer plate will be connected to the gun deck by angle bars which must be of sufficient strength to support the whole pipe. The two inner sheets of the uptake will be secured to these plates as before specified, with oval holes to allow for expansion. From the double plates fastened to the gun deck, the pipe will be well stayed on the outside by angle or T iron, and connected by vertical Z or channel iron. This spacing will be carried to the top of the pipe.

The pipe for the auxiliary boilers will join the uptake between the gun and the protective decks, as shown, and will be similarly supported and stayed.

The lower half of the round inner pipe will be made of No. 7 B. W. G. iron or steel, and the upper half of No. 9 B. W. G. It will be finished at the top by angle bars. It will also have a hood to which stay shackles will be secured for slinging painters. It will extend down over the outer pipe, leaving a sufficient area for the escape of the heated air. The outer pipe will be of No. 12 B. W. G., strongly stayed to the inner. It will be butted and strapped on the inside and flush-riveted on the outside. It will extend within about 6 inches of the hood at the top.

The pipes will be stayed by three rows of guys and turnbuckles, one row near the top of the inner casing, one row about 30 feet from the deck, and the other row about halfway between the two. There will be four guys in the upper row, two in the second row, and four in the lower row. The guys will lead fore and aft, and athwartships in the upper and lower rows and athwartships only in the center row.

The shackle bolts will extend through both pipes, passing through a thimble between them, having a nut on the inside, with collar on the outside. There will also be a band around the pipe at each row of guys 6 inches by ¼ inch, riveted to outside casing.

From the upper deck to 6 feet above it, there will be a casing surrounding the outer pipe and 6 inches from it, of No. 12 B. W. G. Above the top of the casing will be an umbrella and curtain, finished on the edge with half-round iron, to prevent water coming down the casing, and leaving space sufficient for the exit of the air.

There will be a ladder on the outside of each pipe on the forward side, extending to the top. This ladder to be made of round iron, bent and riveted to the pipe.

There will be doors through the casings and pipes, about on a level of the berth deck, large enough to admit a man.

115. SMOKEPIPE COVERS.

An approved canvas cover will be furnished for each smokepipe.

116. BOILER SADDLES.

Each auxiliary boiler will be supported by four brackets of plate steel or iron, 1 x 12 inches, with the ends bent to fit the boiler, the central portion forming a triangle, the base of which will rest on a continuous keelson or shelf built in the ship. Each end of each bracket will be bolted to the boiler by four 1-inch bolts extending through the shell and having a nut on the inside and also tapped into the shell, and to the keelson by four 1⅛-inch bolts.

The bolt holes in the base resting on keelson will be oval to allow for expansion.

The main boilers will be supported in an approved manner.

117. BOILER ATTACHMENTS.

Each boiler will have the following attachmets, viz :

One steam stop valve.

One dry pipe.

One feed-check valve with internal pipe.

One bottom blow valve with internal pipe.

One surface blow valve with internal pipe and scum pan.

One safety valve to be connected with dry pipe or have internal pipes.

One steam gauge.

Two glass water gauges of approved automatic closing pattern on the main and one on the auxiliary.

Four gauge cocks.

One sentinel valve.

One salinometer pot, except for main boilers, where there will be one for each pair.

One drain cock.

One air cock.

One approved circulating apparatus.

One cock with thread for the attachment of a syringe.

All external fittings will be of composition unless otherwise directed. All fittings will be flanged and through-bolted or attached in other approved manner. All cocks, valves, and pipes will have spigots or nipples passing

through the boiler plates. All internal pipes will be of brass, No. 14 B. W. G., and must touch the plates nowhere except where they connect with their external fittings. The internal feed and blow pipes will be expanded in the holes in boiler shells to fit the nipples on their valves, and will be supported where necessary in an approved manner. The stems of all valves on boilers are to have outside screw threads. The internal feed and blow pipes are to be arranged to come between the corrugations of furnaces.

118. BOILER STOP VALVES.

There will be a 3¼-inch self-closing stop valve, with horizontal spindle, on each main boiler, and one 3½ inches diameter on each auxiliary boiler, each bolted to a nozzle connected with the dry pipe; this nozzle to have a 3-inch branch for attachment of the safety-valve chamber.

A screw sleeve, with suitable hand wheel, will be fitted for closing the valve; also a spindle and handle for opening the valve.

The stop valves on all the boilers will be located as directed.

The wheels on all boiler stop valves will have rims covered with wood.

119. DRY PIPES.

There will be in each auxiliary, and, if directed, in each main, boiler, as high as possible, and properly supported, a brass or tinned copper dry pipe, extending nearly the length of the boiler, perforated on its upper side with longitudinal slits of such a number and size that the sum of their areas will equal seven-eighths of the area of the stop valve. The pipes will be 3¼ and 3½ inches diameter, respectively, for the main and auxiliary boilers. All joints on the pipes inside the boilers will be made steam tight.

120. FEED CHECK VALVES.

There will be a 1½-inch check valve on each boiler. They will be placed at front ends of the boilers, and be

For each auxiliary boiler

fitted with internal pipes leading above the tubes and pointing downward in the water spaces between the nests of tubes and between the nests and shell, ~~as shown~~.

The valve cases will be so made that the bottom of the outlet nozzle shall be at least ½ inch above the valve seat. The valves will be assisted in closing by phosphor bronze spiral springs. These valves will have polished brass bent bar handles in lieu of hand wheels.

The feed check valves will have stop valves between the check valve and the boiler.

121. SAFETY VALVES.

Each boiler will have one 3-inch spring safety valve placed on the stop-valve nozzles.

Each valve will have a projecting lip and an adjustable ring for increasing the pressure on the valve when lifted, or an equivalent device for attaining the same result. They will be adjustable for pressure up to the test pressure—the adjusting mechanism to have an index to show the pressure at which the valve is set, and a lock to prevent tampering with the adjustment. The locks on all safety valves will be alike. The springs will be square in cross section, of first quality tool steel, and will be nickel-plated. They will be of such a length as to allow the valves to lift one-eighth of their diameters when the valves are set at 160 pounds pressure for the auxiliary and 250 for the main boilers. They will have spherical bearings at ends, or be connected to the compression plates in such a manner as to insure a proper distribution of pressure. They will be inclosed in cases so arranged that steam will not come in contact with the springs. The spring cases will be so fitted that the valves can be removed without slacking the springs. The valve stems will fit loosely in valves, to bottom below the level of the seats, and to be so secured that the valves may be turned by a wrench or cross-bar on top of stem. The valves will be guided by wings below and in an approved manner above. The valves will be fitted with mechanism for lifting by hand from main deck and

fire rooms. All joints in the lifting gear will be composition bushed. The outlet nozzle will be in the base casting, so that the joint at the escape pipe will not have to be broken when taking the valves out. The casings, valves, and spindles will be made of composition. The valve seats will be of nickel or equivalent metal of approved kind. A drain pipe leading to the bilge will be attached to each safety valve casing below the level of the valve seat.

122. SENTINEL VALVES.

Each boiler will have a sentinel valve of ½ square inch area. They will be spring safety valves set to blow at the working pressure, and will be placed at the same end of the boilers as the check valves.

123. BOTTOM BLOW VALVES.

There will be a 1½-inch composition bottom blow valve on each boiler, bolted to the shell near the front. The valves will close with the boiler pressure. An internal pipe will lead from each valve to near the bottom of the boiler.

124. SURFACE BLOW VALVES.

There will be a 1¼-inch surface blow valve on each boiler, bolted on or near the front. The boiler pressure will be above the valve. An internal pipe will lead from each valve to near the water line in the boiler, and will be fitted with a scum pan. The valve casing and hand wheel will be of composition.

125. BLOW PIPES.

A 1½-inch pipe will connect with all bottom blow valves in each compartment and with a sea valve in the same compartment. This pipe will have a nozzle for the connection of a pipe for pumping out the boilers, as well as 1¼-inch nozzles for attachment of pipes from the surface blow valves. There will be a straightway valve in the blow pipe as near the sea valve as possible.

All joints will be flange joints.

126. BOILER PUMPING-OUT PIPES.

A 1½-inch pipe will connect the bottom blow pipe in each compartment with the auxiliary feed pump in the same compartment, with a screw-stop valve above the floor near the pump.

127. STEAM GAUGES.

There will be a spring steam gauge on each auxiliary boiler and one on each main boiler. The gauges will have seamless tubes and 8½-inch dials, graduated to 255 pounds for the auxiliary, and to 360 for the main boilers, and will have the double Bourdon tube. This gauge will have an independent connection with the boiler and be fitted with a three-way cock, a drain cock at the lowest part of the steam pipe from the boiler, and a coupling for attachment of a test gauge.

128. BOILER WATER GAUGES.

Each main boiler will have two glass water gauges, and each auxiliary one, all to be of approved automatic closing pattern. Each gauge will be placed at the side of the boiler and will have 1½-inch pipes leading to top and near bottom of boiler, with a valve in each close to boiler, the two gauges at the same end being placed on opposite sides and as far apart as possible. The shut-off and blow-out cocks are each to have a clear opening at least ¼ inch in diameter. The glasses will be about 16 inches in exposed length, with the lowest exposed part about 1 inch above the highest heating surface. They will be ¾ inch outside diameter. The glasses will be well protected. A brass index plate, with letters and arrows cast in relief, will be fixed close to the gauge glasses to show the height of the top of combustion chamber. The blow-out cocks will have drain pipes leading to bilge with union joints, ½ inch inside diameter.

129. GAUGE COCKS.

There will be four gauge cocks or valves on each boiler. The valve chambers will have two seats, the inner one formed in the casting and the other movable, screwed into the casting and furnished with a handle.

The valve will have two faces, and will be closed by screwing down the movable seat and will be opened by the pressure in the boiler when the outside seat is slackened off. There will be a guide stem on each side of the valve, the valve and stem being turned from one piece of rolled manganese bronze or Tobin's metal; the stem on the inner side being square and also on the outside of the outer seat to ¾ inch beyond it. It will be of a circular section where it passes through the movable seat. The opening of the valve will be at least ⅜ inch in diameter, and the discharge from the chamber will be at least ¼ inch diameter. Each cock will be independently attached to the boiler. They will be spaced about 3 inches vertically, the lowest one being about 2 inches below the highest heating surface.

Each set will have a drip pan and a ¾-inch copper or brass drain pipe leading to the bilge.

The castings will be sufficiently strong to avoid being broken under ordinary circumstances.

130. SALINOMETER POTS.

There will be a salinometer pot of approved pattern connected to each auxiliary, and one to each pair of main boilers. They will be placed in the fire rooms where directed.

131. BOILER DRAIN COCKS.

Each auxiliary boiler will have a 1-inch drain cock of approved pattern.

132. BOILER AIR COCKS.

Each boiler will have a ½-inch air cock at its highest part, with a ½-inch copper pipe leading to bilge.

133. CIRCULATING APPARATUS.

There will be fitted to each boiler an approved device for circulating the water. It will be of such design that the water will be circulated when the feed pumps are in operation, and will have a steam connection for circulating before steam is raised.

134. ZINC BOILER PROTECTORS.

Each boiler will have rolled zinc plates, 12 x 6 x ½ inch. Each plate will be bolted to wrought-iron straps, which will be clamped to the stays. Each strap will be filed bright where in contact with zinc and stay, each stay being also filed bright at contact point. After being bolted in place the outside of the joints will be made water-tight by paint or approved cement. The zinc plates will be located as may be designated by the Bureau of Steam Engineering, and there will be 1½ square feet of exposed surface exclusive of edges for each 100 square feet of heating surface in the boilers.

Surrounding the zinc and bolted to the stay will be placed baskets of ⅛-inch steel plate to catch the zinc when disintegrated. The baskets will have six ⅝-inch holes in the bottom.

135. FEED PUMP PRESSURE GAUGES.

Each main and auxiliary feed pump will have a spring pressure gauge registering from zero to at least 360 pounds per square inch.

136. ASH HOISTS.

One ventilator in each fire room will have vertical guide strips of iron on the inside and be fitted with all the necessary gear for hoisting ashes.

An ash-hoisting engine of approved design will be fitted in each fire room hatch or in such place as may be directed, of sufficient power to hoist 300 pounds from the fire room floor to the deck in five seconds with steam of 80 pounds pressure.

It will have a reversing gear, to be worked from the fire room and from deck, with approved adjustable safety gear to prevent overwinding and to stop the engine when the ash bucket reaches the fire room floor. It will also be fitted with an approved brake to control the drum. The ash hoist will be fitted with the necessary sheaves, whip, and all appliances necessary for handling ash buckets; also with a bell with pulls in the fire room and

on deck, to be used as a signal for hoisting and in lowering.

137. ASH EJECTOR.

An approved ash ejector will be fitted in the forward fire room. Water for it will be supplied by the auxiliary pump in that fire room.

138. COAL HOISTING ENGINE.

There will be one coal hoisting engine capable of lifting 1,000 pounds at 300 feet per minute, located where directed.

139. FIRE ROOM BLOWERS.

There will be one blower of approved pattern in the after fire room and two in the forward one.

These blowers must be capable of supplying to the fires continuously, with ease, sufficient air to maintain the maximum rate of combustion. They will take air from the fire rooms so as to thoroughly ventilate them, and deliver into the main air ducts, as shown.

The spindle bearings must be accessible while the blowers are in motion, and will be of anti-friction metal, fitted in composition boxes, and, together with their lubricating apparatus, must be thoroughly protected from dust.

If the blowers are fitted with casings, the casings must be so made that they can be removed without cutting out rivets.

140. BLOWER ENGINES.

Each blower will be driven direct by a balanced engine of two or more cylinders of an approved design and of sufficient power to run the blower at full speed with steam of 100 pounds boiler pressure. The engine valves must be of the slide or piston type.

All working parts must be closed in, but easily accessible for overhauling. The lubrication must be automatic and thorough, and such that the dust in the fire room can not come in contact with the oil. The throttle valve in the steam pipe of each blowing engine will be arranged to be worked from the fire room floor, with suitable index

to show how much it may be open. The steam pipe for each blower will connect with the auxilary steam pipe.

The shafts of blower engines will be so fitted that a portable revolution indicator can be quickly and easily applied without removing any part of the mechanism.

141. AIR-PRESSURE GAUGES.

A gauge of a pattern approved by the Bureau of Steam Engineering will be fitted in each fire room to show the air pressure.

A portable gauge will also be supplied to each fire room, with convenience for connecting it to the furnaces, uptakes, and wherever it is desired to measure the air pressure.

All these gauges will indicate pressure in inches of water.

142. FIRE TOOL RACKS.

Racks will be fitted in each fire room in convenient places for holding all necessary fire tools.

143. ASH DUMPS.

From each ash hoist, on the upper deck, permanent overhead rails, suitably supported, will lead to the nearest ash chute on each side of the ship, if directed. Each of these will be fitted with a traveler of approved design, with all necessary appliances for carrying the ash buckets. At the top of each ash chute a dumping hopper of approved design will be fitted, so arranged as to fold up out of the way when not in use. Arrangements must also be made, either by a temporary chute or other approved manner, for dumping ashes from either side into a lighter. The ash buckets are to be balanced dump buckets, with all necessary gear complete. All the ash hoisting and dumping gear will be such that the buckets will not have to be lifted by hand.

144. ASH SPRINKLERS.

A valve for wetting down ashes will be fitted in each fire room, where directed, and will be fitted with all necessary hose, couplings, nozzles, and reels or racks.

145. STEAM TUBE CLEANERS.

A steam tube cleaner of approved design will be fitted in each fire room. Steam will be taken from the auxiliary steam pipe. Sufficient length of steam hose will be provided to easily reach all the tubes.

146. WORKSHOP MACHINERY.

There will be fitted in the engineer's workshop the following tools, arranged to work by hand and power, to be of the best make and to be approved by the Bureau of Steam Engineering.

1. A back-geared screw-cutting engine lathe, to swing 12 inches over ways and take 46 inches between centers. It will be fitted with gear for cutting threads from 4 to 32 to the inch, and with four grade cone pulleys.

It will have a hollow spindle on the driving head, with hole 1½ inches diameter. The carriage will have automatic cross feed. The lathe to be fitted with scroll and drill chucks. Weight not to exceed 800 pounds. Bed not to exceed 6 feet in length.

2. A column shaping machine, of 15 inches stroke and 15 inches traverse, with vertical adjustment to table and arbor for circular planing; to have at least two grade cone pulleys, and be fitted with chuck. Weight not to exceed 1,000 pounds.

3. A double-geared drilling machine with screw feed; to have three grade cone pulleys, and be capable of drilling from ½ inch to 1½ inch holes; to have adjustable swinging table; to swing 12 inches.

4. An emery wheel 12 inches diameter and 1-inch face.

A vertical engine will be provided to drive these tools; engine will have fly wheel, driving pulley, and automatic governor; to make about 160 revolutions per minute.

The tools above specified will be erected and fitted where directed in the engineer's workshop. Each machine will be driven from a countershaft with cone pulleys to suit the machine.

Countershafts, hangers, and pulleys will be provided for each of the above tools.

147. DISTILLING APPARATUS AND EVAPORATORS.

The distilling apparatus, placed where directed, will consist of one evaporator and two distillers, with their accessories, having a combined capacity of 4,200 gallons of potable water per twenty-four hours at a temperature of not more than 90° F.

The evaporators will be made with shells of plate steel. They will be either horizontal or vertical, and will be subject to the approval of the Bureau of Steam Engineering. The tubes will be of such design that they can be readily removed for scaling or repair, with adequate provision for expansion, and will be secured to the tube sheet in an approved manner. They will be either straight, bent, or coiled, as the Bureau of Steam Engineering may approve. The tubes must be so arranged that after the system is removed from the shell it will be accessible in all its parts for scaling. It will be felted and lagged, and will be fitted with a safety valve, steam gauge, glass water gauge, salinometer pot, and blow valve. It will take steam from the auxiliary exhaust pipe and also from the auxiliary steam pipe, and will be fitted with automatic traps and with drainpipes leading to the suction pipes of the auxiliary air pumps. The branch from the auxiliary steam pipe will be fitted with an approved reducing valve. The shell of the evaporator will be tested to 50 pounds to the square inch, and the coils and all parts subject to boiler pressure to 230 pounds per square inch. It will have at least 130 square feet of heating surface. The distillers will be made with shells of sheet brass, flanges and heads of composition, and coils of copper or brass, thoroughly tinned on both sides. The coils of each distiller will be divided into at least two parts, each with a separate inlet and outlet valve.

A water-tight filter, of approved design, will be fitted for both distillers. The connections to it will be so made that the cover may be readily removed and replaced, so that either or both distillers may discharge into it, and so that both may connect directly with the fresh water end of the combined pump.

Refrigerating Plant. 116 - O
L and R. informs Bureau
that Dept. directs refrigerating
apparatus to be omitted.

There will be efficient means for aërating the steam used in making distilled water.

There will be a combined pump of approved size for pumping distilled water from the distiller to fresh-water tanks, through filter, or to the main feed tanks, and to draw brine from the evaporator and discharge it into the circulating pump discharge beyond the feed suction. This pump to be so connected that the brine end may also be used as a feed pump for the evaporator.

The fresh-water cylinder will have no copper or lead, and will have a pipe leading from its suction pipe to above the awnings with a regulating valve so that air can be forced into the tanks with the water. In the water discharge of this pump will be fitted an approved water meter, made without copper or lead. The discharge pipes of this pump will lead to the bottom of the fresh-water tank so that the air forced in will rise through the water.

Provision will be made for feeding the evaporator with the circulating water which has passed through the condenser. The pipe to have a check valve in it close to evaporator.

The condensing water after leaving the distillers will run into the fire main. A check valve will be put in the discharge pipe close to distiller so that pressure from the fire main may not come on the coils.

The evaporator and distillers will be so fitted that their coils can be easily removed for repairs. There must be no internal detachable joints in the coils either of evaporator or distillers.

148. REFRIGERATING PLANT.

There will be an ice machine of the "dense air" variety capable of making one ton of ice per day. It will have cooling pipes, as directed, to the ice tank, to the cold storage or refrigerating room, and to the scuttle butt.

The engine must be built with sufficient clearance between crossheads and stuffing box packing nuts or glands to permit of setting them up while the engine is running.

Valves will be provided so that the air may go to the

refrigerating room direct, or through the ice-making tank and thence to the refrigerating room and scuttle butt; and also from the ice-making tank directly to the scuttle butt.

The pipe in the scuttle butt will be of copper, well tinned on the outside.

149. WASH-WATER TANKS, ETC.

There will be one or more wrought-iron tanks, of a combined capacity of 150 gallons, to hold fresh water for firemen's use. They will be fitted in such places as may be designated. Each tank will have an overflow pipe, without valve or cock, leading to the bilge, with the end in plain view from the fire room; also a drainpipe with its valve easily reached from the fire room. A pipe will be led direct from the fresh-water outlet of the distiller for filling these tanks without passing the water through the filter; this pipe to have a locked cock.

There will be an approved hand pump connected as follows: To have suction pipes from the feed-tank suction pipe and from the tanks above mentioned, and to discharge into these tanks and into the tank in the firemen's washroom; all pipes fitted with stop valves close to the pump. The pump will have a dead-weight relief valve set at just sufficient pressure to allow the washroom tank to be filled.

A cylindrical copper tank of about 30 gallons capacity will be fitted in the firemen's washroom, and connected with the pump above specified. The tank will be supplied with a vent pipe with a float valve, which will close the vent when the tank is full. There will be a service pipe from the tank, with a branch to each wash basin, and one for filling buckets. Each of these branches will have a self-closing lever faucet. In the service pipe, close to the tank, will be a locked cock.

150. MAIN STEAM PIPES.

The main steam pipes will be of copper, the thickness in accordance with the formula hereinafter furnished.

The pipes from each of the stop valves on the forward boilers will be 3¼ inches in diameter, 4 inches where the

branches from each pair unite, and 5¾ from the junction of the 4-inch branches to the T piece in engine room, the branches from this to the high-pressure cylinders being 4 inches. There will be a straightway valve in this pipe on the after bulkhead of each boiler compartment, and a separator in it in the engine room; all as shown on the drawing.

The pipes from the after or auxiliary boilers will be 3½ inches in diameter and 5 inches from the junction of the two pipes to the T piece in engine room, from which point 3½-inch branches will run to the first intermediate cylinders with straightway valves close to cylinders. There will be a straightway valve in this pipe on the after bulkhead of the fire room, and a separator in the engine room, as shown on the drawing. A 5-inch branch will connect this pipe in the fire room with the pipe from the forward boilers, and be provided with a self-closing stop valve. All straightway valves to be provided with by-pass valves. Suitable and approved means must be provided for taking up expansion in the steam pipes, and all T's and short bends must be made of composition of approved thickness.

151. AUXILIARY STEAM PIPES.

There will be an auxiliary steam pipe extending through engine and boiler compartments and to all the steam engines in the ship. It will connect with the stop valves on each auxiliary boiler, and will be of sufficient size to supply all the auxiliary machinery. There will be a stop valve in the after part of each boiler compartment, close to the bulkhead. Wherever pockets necessarily occur the pipe will be drained and trapped. All branches from the pipe to pumps or engines on a lower level will have the stop valve for such machinery close to the main pipe, so that when the pump or engine is standing idle there will be no opportunity for water to collect in the vertical pipe leading to it. All branches to engines above the protective deck will have stop valves below that deck.

A separate auxiliary steam pipe will be fitted connecting the dynamo engines with the auxiliary boilers; there

will be a stop valve on each boiler, and the pipes will lead as direct as possible to a separator placed near the dynamo engines; all dips and pockets to be carefully avoided. Valves will be fitted so that the branch leading to either boiler may be shut off when the boiler is not connected with the dynamo engine pipes, and valves will be fitted in the pipes leading from the separator to each engine, so that the steam may be shut off from the pipes when the engine is not in use. The traps for the separators must be of the proper size, and will be fitted with by-pass pipes and valves, so that they may be cleaned without shutting steam off from the engines. There will be an approved reducing valve in the dynamo engine steam pipe, placed as near the boilers as possible, with a steam gauge in the fire room.

The drain pipes must be so fitted that it will be impossible for one dynamo engine to blow into another, or for one end of one cylinder to blow into the other end of the same cylinder.

Swing checks will be fitted in all drain pipes close to the cylinder or chest from which they lead, and the drain pipes will be joined by an approved Y or T. The drain pipes from the cylinders must lead to the feed tank or into the exhaust pipe.

A plan of the piping and drains will be submitted to the Bureau of Steam Engineering for approval before any of the work is done upon it.

152. AUXILIARY EXHAUST PIPES.

An auxiliary exhaust pipe, of sufficient size for all auxiliary machinery herein specified, and for such other steam machinery as may be fitted in the vessel, will be fitted and connected to all auxiliary machinery. It will have valves to direct the exhaust steam into either main condenser, into either second intermediate-pressure receiver, or into the atmosphere through the escape pipe at will. At each connection with condensers and escape pipe the auxiliary exhaust pipe will be fitted with two stop valves so as to minimize the chance of an air leak.

The connection with the escape pipe will be made below the protective deck.

All exhaust pipes from engines above the protective deck leading to the condenser will be fitted with valves below the armored deck.

The dynamo engine exhaust pipes must be so led and joined by an approved **Y** or **T** that one engine can not exhaust against another, or the unused engine be flooded, and swing check valves will be fitted in all exhaust pipes close to the valve chests.

153. BLEEDER PIPES.

A 3-inch branch will lead from the main steam pipe of each engine to its main exhaust pipe, with a stop valve operated from the working platform.

154. INTERMEDIATE-PRESSURE STEAM PIPES.

A 1½-inch branch from the main steam pipe will lead to each first intermediate-pressure valve chest, each with a stop valve.

155 SEPARATORS.

There will be in each main steam pipe in the engine room a centrifugal or other approved separator. They will be made entirely of cast steel and plate steel, each fitted with a well protected glass gauge of the automatic closing pattern, and an approved automatic steam trap, with drain delivering into feed tank. There will also be a drain connected directly to the separator, discharging into the feed tanks.

156. MAIN FEED PUMP EXHAUST.

The exhaust pipes from the main feed pumps, in addition to the connection with the exhaust main, will be so arranged that the exhaust steam can be turned into the feed pump suction chambers; suitable nozzles for this purpose being fitted in the suction pipes.

157. ESCAPE PIPES.

There will be a 5-inch copper pipe abaft each smoke-pipe, extending to its top, finished and secured in an approved manner. This pipe will have branches leading to all the safety valves in its compartment.

The auxiliary exhaust pipe will connect with the after escape pipe.

158. FEED PIPES AND FEED PUMP SUCTIONS.

There will be one feed main connected with the main and auxiliary feed pumps. It will run from the main feed pumps in the engine room, along the port side of the ship as far as the forward boiler room, where it will have branches to the check valves. There will be similar branches in the after fire room, and the valves in each fire room so arranged that any pump may be used on either or all boilers.

Each main feed pump will have a suction from each feed tank on the pipe before specified connecting the feed tanks; and also one from the fresh-water tanks on the same side of the vessel. Each will deliver into either or both of these tanks, through the main feed pipe, with suitable valves in the branches to so direct the water.

Each auxiliary feed pump in fire rooms will connect with the same suction pipe as the main feed pumps, and be provided with a valve just forward of the connection.

The feed delivery pipes will be led as high as possible above the floors, and the suction so that joints may be easily reached.

In addition to the suction from the feed tanks the pumps in the fire rooms will be arranged to draw from the main drain, from the fire room bilge direct, from the air ducts, from the boilers and from the sea; and to discharge overboard and into the fire main in addition to the feed discharge. All valves to be straightway except boiler checks, pump manifold, and sea valves. A plan of the piping must be submitted for approval before the work is started.

159. FEED-WATER HEATER.

If directed, there will be for each fire room a feed-water heater of suitable size, placed where directed. Plans showing the type and arrangement of heater must be submitted to the Bureau of Steam Engineering for approval before work is commenced on them.

160. BY-PASS VALVES ON STRAIGHTWAY VALVES.

All straightway valves above 5 inches in diameter, subjected to pressure above 15 pounds per square inch, will have by-pass valves to relieve the valve when jammed on the seat.

They will be for straightway valves above 5 and to 8 inches, 1 inch in diameter; above this, 1½ inches.

161. FIRE MAIN.

There will be a fire main of copper, 4 inches inside diameter, extending through the engine and fire rooms, from the after end of the engine hatch to the forward fire-room hatch, located above the floor plates and below the protective deck.

From this main at the engine and at forward end of fire room hatches, there will be two vertical branches extending to the upper deck (six in all), each branch 3 inches in diameter. From each of these vertical branches on each deck above the protective deck there will be branches passing through the bulkheads surrounding the hatches with straightway valves and hose connections on each branch outside the hatch.

Leading forward from one of the vertical branches in the forward hatch there will be a branch connecting to a hose nozzle in the magazine passing room and in the sick bay.

There will also be a branch leading aft from one of the vertical pipes in the engine hatch to the after magazine passing room. Each of these branches, forward and aft, will have a straightway valve outside the hatch and also one immediately back of the hose nozzles.

These branches will be led in such a manner as to avoid any interference with bulkheads or head room, or as may be decided upon by the Inspecting Constructor and Engineer.

Branches will lead from the fire main forward and aft to the head and to the wardroom, cabin and sick-bay, water closets, and bath rooms, with valves at the junction of the branches with the main.

Each pump mentioned in these specifications to be used as a fire pump will be connected with this main under the protective deck.

There will be a hose nozzle at the end of the each engine room, and one in each fire room, each connected to the fire main by a branch with a straightway valve between the main and the hose coupling.

All couplings will be for 2½-inch hose fitted with standard Navy thread.

There will be a reverse hose coupling on the auxiliary feed pipe for filling the boilers from a hose.

There will be a 1½-inch steam pipe leading from the auxiliary steam pipe to each bunker and hold for extinguishing fire. This pipe will have a valve in it next the auxiliary steam pipe and another at each coal bunker and hold bulkhead. The part inside of the bunker may be made of galvanized iron, all other pipe of copper.

All valves in the fire main and steam extinguishing pipes with the pipes from the pumps will be straightway composition valves. Drainpipes will be fitted to drain all parts of fire main and branches.

162. PIPES THROUGH WATER-TIGHT BULKHEADS AND DECKS.

They will be made water-tight by stuffing boxes; flanges of pipes must not have their joints made on bulkheads.

Pipes must not be led in such a manner that the angles or T's of bulkheads have to be cut. Holes through wooden decks, where pipes pass through, will have brass or copper thimbles, made water-tight, extending at least 3 inches above decks.

163. PIPES THROUGH COAL BUNKERS.

They will be protected by iron casings, made in sections, easily removable for repairs. Pipes must not be led under openings of coal chutes.

164. DRAIN PIPES AND TRAPS.

All places where condensed steam can accumulate will be provided with drain pipes and cocks or valves of ample size, and with approved automatic traps, which will discharge into feed tanks or condensers, or as directed. All traps will have by-pass pipes and valves for convenience of overhauling. The lowest parts of all water pipes and all pump cylinders and channel ways will have drain cocks with pipes, where required. The handles of all drain cocks will point downward when closed. All glass water gauges under pressure will be fitted with valves of approved automatic closing pattern.

165. THICKNESS OF PIPES.

The thickness of copper straight steam piping, fire service, and blow-off pipes will be found by the following formula:

$$\frac{P \times D}{8000} + \frac{1}{16} = T.$$

Where P = boiler pressure above atmosphere.
D = inside diameter of pipe.
T = thickness in inches.

The thickness of feed pipe will be found by the same formula with the exception that P = 1.5 boiler pressure above atmosphere.

The thickness for feed-suction piping will be $\frac{1}{8}$ inch.

Water pipes without pressure will be—

Of 2 and less than 5 inches, $\frac{3}{32}$ inch.

Of 5 inches and over, $\frac{1}{8}$ inch.

All copper piping will be $\frac{1}{10}$. 1 B. W. G. thicker in the bends than in straight parts.

All exhaust and other pipes not in the above list will be made of approved thickness.

166. MATERIAL AND FITTING OF PIPES.

All pipes, except the lower end of bilge-suction pipes, will be of copper, unless otherwise specified.

The lower parts of bilge-suction pipes will be of galvanized iron. All copper and brass piping of and less than

6 inches diameter will be seamless drawn. All copper pipes not seamless drawn will be brazed. All copper pipes over 5½ inches in diameter will have composition flanges riveted on and brazed, and will have the end of the pipe expanded into a recess in the face of the flange. All feed and blow pipes will have composition flanges. All flanges of high-pressure pipes will be in accordance with the Bureau of Steam Engineering table of thickness of pipes and flanges, and will be faced and grooved, and joints between flanges in steam pipes will be made with asbestos board soaked in boiled linseed oil, "Usuduran" with wire gauze, "Vulcabeston," or other material, samples of which must be submitted to the Bureau of Steam Engineering for approval before using.

For pressures greater than 160 pounds per square inch, flanges will be of special construction, the design to be furnished or approved by the Bureau of Steam Engineering.

No material will be used that will not withstand the heat of the steam and keep tight an indefinite length of time, and any material used must be the best that can be procured. All composition flanges below the floor plates will be connected by bolts and nuts of rolled naval brass or Tobin bronze. All copper pipe T pieces and fittings will be of composition, except where otherwise directed. Expansion joints of approved pattern will be fitted where required. Slip joints, if fitted, will have stop bolts and flanges. All copper pipes in bilges will be well painted, and must not rest in contact with any of the iron or steel work of the vessel.

All steam, air, and water pipes of refrigerating plant, except those in the refrigerating room, will be of copper, with flange joints; all other pipes will be fitted with flange joints, to be approved by the Bureau of Steam Engineering. The piping in the refrigerating room will be of galvanized iron, and that in the scuttle butt of copper, well tinned on the outside.

All slip joints will consist of a composition stuffing box, follower, and entering pipe, the stuffiing box and en-

tering pipe to be connected by flanges with the copper pipe.

All slip joints to be packed with metallic packing to be approved by the Bureau of Steam Engineering.

167. AUXILIARY ENGINE STOP VALVES.

Each auxiliary engine will have stop valves in exhaust pipes as close to cylinder as possible. Exhaust stop valves will be straightway where practicable. All pumps, except circulating pumps, will have screw check valves in both suction and delivery pipes close to pump cylinders, so arranged that they may be kept off their seats when desired.

168. SEA VALVES.

There will be in the various compartments sea valves as follows:

In the engine compartment a screw-top valve, having independent connection to the side of the vessel, of sufficient size to supply water to the fire and bilge, and the water service pumps in that compartment. Also a screw non-return valve for the discharge from the fire and bilge pump. The main injection and outboard delivery valves will be as elsewhere specified.

In each boiler compartment there will be a screw stop valve for a bottom blow, pump discharge, and sea suction. These valves to also have nozzles cast on for ash wetting.

All these valves will be of composition, with the screws on the stems outside the chamber, the screws passing through a crosshead supported by iron or steel stanchions.

169. BILGE STRAINERS.

Each pipe leading from the bilges or from the drainage system of the vessel to the pumps will be fitted with a Macomb (or approved equivalent) strainer, above the floors.

The baskets of Macomb strainers will have a diameter equal to one and one-half times the diameter of the pipe, and a length equal to twice the diameter of the pipe, except in the case of the bilge injections, which strainer will be the same diameter as the pipe.

170. ATTACHMENT OF VALVES TO HULL.

Steel strengthening rings will be riveted to plating of hull around the openings for all sea valves. The valve flanges will be bolted to these rings by rolled manganese or Tobin bronze studs, care being taken not to drill the holes entirely through the rings. A zinc protecting ring will be fitted in each opening in outer skin in such a manner as to be easily renewed.

All suction valves will have strainers over their openings on the outside of the vessel. These strainers will have $\frac{5}{8}$-inch holes with a collective area equal to twice the area of the valve openings. Strainers must be fastened to valve pipes or casings, and not to the plates of the hull.

All sea valves over the double bottom will be inside the inner skin and connected to the outer skin by a cast or plate steel pipe, secured by riveted flanges to both inner and outer skins. There will be a steel stiffening ring on the inner bottom, to which the valve chamber will be bolted. A zinc protecting ring will be secured to the lower flange of the valve chamber.

171. COCKS AND VALVES.

All cocks and valves and their fittings, except as otherwise specified, will be of composition. All hand wheels will be of finished brass, except as otherwise specified, and will be at least one and one-half times as great in diameter as their valves. All cocks communicating with vacuum spaces will have bottoms of shell cast in and have packed plugs. All cocks over 1 inch in diameter will have packed plugs. Reducing valves will be put in where directed or required.

Valves of approved pattern will be supplied wherever necessary to complete the various pipe systems, whether herein specified or not. All valves will be so fitted as to be easily ground in, and be fitted where required with grinding-in guides and handles. No conical-faced valve will have a bearing on its seat of more than $\frac{3}{16}$ inch in width. All valve spindles must turn right-handed to close, and have outside threads where practicable. Cocks

and valves may have, where approved, in lieu of wheels or permanent handles, removable box or socket wrenches, marked and stowed in convenient racks; these handles to be so fitted that they can only be removed when the valves are closed. All cocks and valves underneath the floor plates will have their wheels or handles above the floor plates, in easily accessible positions, unless otherwise directed.

The sizes of valves as given in these specifications refer to the diameter of the equivalent clear openings.

172. LABELS ON GEAR AND INSTRUMENTS.

All cocks will have engraved brass plates to show their uses and to indicate whether open or shut. All valves, except such as may be otherwise directed, will have similarly engraved plates to show their uses, or have the same plainly engraved on hand wheels.

All hand levers or their quadrants will be similarly marked. Gear for working valves from deck will be marked as elsewhere specified.

All main steam stop valves will have indices to show to what extent they are opened.

All gauges, thermometers, counters, telegraph dials, speaking tube annunciators, and revolution indicators will be suitably engraved to show to what they are connected.

All engraving will be deep and be filled in with black cement.

173. CLOTHING AND LAGGING.

The main cylinders and valve chests, excepting upper cylinder heads, after being finally secured in place in the vessel and tested, will be covered with approved incombustible nonconducting material and neatly lagged with black walnut all over, secured with polished brass bands and round-headed brass screws. The upper cylinder heads will be covered with black walnut lagging with a sheet of asbestos board beneath it.

The lagging will be made in removable sections over each valve chest and manhole cover, parts plainly marked.

The lagging elsewhere will be so secured as to be easily removed, replaced, and repaired.

All parts of the condensers except the water chests at ends will be clothed with approved material put on in sections so as to be easily removed and replaced, and neatly lagged with Russia sheet iron secured by brass bands.

All steam and exhaust pipes, the separators, the feed-water heaters, and all steam valves will be clothed in an approved manner with a satisfactory nonconducting material, covered with No. 6 canvas in addition to that usually covering the nonconducting material; this canvas to be sewed on and be well painted. The main steam and exhaust pipes in engine room and the separators will be also covered with Russia sheet iron, secured with brass bands. Where bends occur, this sheet iron shall be made so that the covering of the entire bend is in only two pieces. The canvas covering of steam pipes will be secured to bulkheads where the pipes pass through them.

The main steam pipes, where they pass through bunkers, will in addition be inclosed in a water-tight covering of galvanized iron.

The steam cylinders of all auxiliary engines will be clothed the same as main cylinders and lagged with Russia sheet iron or black walnut.

The feed tanks will be covered with ¾-inch cow hair felt, with canvas back, and lagged with black walnut lagging, with brass bands.

The ice-making tank, the scuttle butt, and all piping connected with the refrigerating plant, except that in refrigerating room and in scuttle butt, will be clothed and lagged in an approved manner.

After the boilers are in place and have been tested and painted, they will be covered all over, except where directed, as low as the saddles, with approved incombustible nonconducting material at least 1½ inches thick. This clothing will be covered on tops, sides, and back heads and on fronts, where required, by galvanized

wrought-iron plates, about No. 18 B. W. G., flanged not less than 1 inch and bolted together; also secured to boiler plates at bottom by angle iron, which will be held in place by ½-inch bolts tapped part way into the boiler plates and held off from the boiler plates elsewhere by suitable distance pieces.

174. RADIATORS.

Radiators of approved patterns, with such areas as may be called for in the specifications for radiators to be furnished by the Bureau of Steam Engineering, will be furnished and fitted and connected.

Each radiator or coil of more than 10 square feet will be divided into two parts. All radiators will be fitted with approved valves, with valve-stem guards, and removable keys for valve stems. The ends of the stems will be triangular in cross sections.

The radiators in the wardroom and cabin will consist of pipes led along the deck at the bottom of the bulkheads, and will be covered with an approved metallic casing easily removable.

The steam and drain pipes will be of seamless drawn brass, of iron pipe size, suitably connected by composition fittings in a manner that will permit them to be easily taken down for repairs.

All union joints will be coned or have corrugated copper washers.

All holes through decks and bulkheads will be thimbled with brass.

Steam and drain pipes will be clothed where near woodwork, and elsewhere as required.

The steam pipes will connect with the auxiliary steam pipes where directed, and be fitted with adjustable reducing valves.

The drainpipe of each circuit will have an approved automatic steam trap discharging into feed tank, and elsewhere as directed.

Independent steam pipes will lead from engine and fire rooms to the principal divisions of the officers' quarters and forward parts of the ship.

175. WHISTLES.

An approved polished brass chime steam whistle, with a bell of about 6 inches diameter, will be placed forward of the forward smokepipe, well above the level of the awnings, and connected to the auxiliary steam pipe by a pipe having a stop valve at its lower end and a working valve at the upper end. The pipe will have an expansion joint at lower end.

There will be a shrieking whistle of approved pattern and size placed where directed, and connected similarly to the whistle.

Both whistle connections will have drainpipes fitted at the lowest points.

176. HOSE AND HOSE REELS.

A sufficient length of hose will be supplied for the engine room and for each fire room to lead to the farthest part of the adjoining coal bunkers below the protective deck. The hose for engine rooms will be of the best quality rubber-lined linen, and that for fire rooms will be the best quality four-ply rubber engine hose, all 2½ inches diameter, with standard couplings. Each hose will be supplied with a rubber hose pipe with handles. A pair of spanners will be supplied for each hose nozzle.

A hose reel of approved pattern will be fitted in each fire room, and a swinging bracket or similar hose receptacle in each engine room. Hose pipes and spanners will be fitted in beckets.

177. SHAFTS THROUGH BULKHEADS.

All shafts passing through water-tight bulkheads will be fitted with stuffing boxes, each in two parts.

178. FLOORS AND PLATFORMS.

The engine rooms and fire rooms will be floored with wrought-iron plates ¼ inch thick, with neatly matched flat-top corrugations. The plates will be of convenient size and easily removable. They will rest on proper ledges of angle or **T** iron, and will have drain holes where necessary. Platforms will be provided for getting

at all parts of the main and auxiliary engines and boilers. These platforms, where placed over moving machinery, will be fitted the same as the lower floors. In other places they will be made of iron rods $\frac{5}{8}$ inch square, placed $1\frac{1}{4}$ inches apart.

Floors over tops of cylinders must be so secured that the cylinder covers may be radily removed.

179. LADDERS.

Ladders will be fitted wherever necessary for reaching the engine rooms and fire rooms from deck, and for reaching the various platforms, passages, and parts of machinery. The engine room ladders will be made with plate iron sides and light cast-iron treads with corrugated tops, and the main ladders from deck to engine rooms will be 2 feet wide in the clear. The fire room ladders will be made with plate sides and double square-bar treads.

All ladders will be so fitted as to be easily removable where required, and will be joined and hinged, with necessary fastenings and gear, where they have to be moved when closing hatches. Light iron ladders will be fitted to and through one ventilator in the engine room as means of egress when the battle hatches are closed.

Gear will be provided for quickly opening the battle hatches over the fire room ladders, this gear to be worked from fire rooms.

180. HAND RAILS.

Hand rails, easily removable where required, will be fitted to all ladders and platforms around moving parts of machinery, and along bulkheads and passage ways. The hand rails and stanchions will be made of approved metal which will not easily tarnish, and will be polished all over. The lower ends of stanchions will pass through floor plates with nuts underneath. Stanchions supporting hand rails will be perpendicular to floor plates or treads of ladders.

181. GEAR FOR WORKING VALVES FROM DECK.

The safety valves, boiler stop valves, and valves at fire room bulkhead in main steam pipes, as elsewhere

specified, will have suitable gear for working them from the main deck.

The rods of the gear will be guided and supported on deck by composition standards, left rough and painted. Each rod will have polished brass bar handles fitted to squares on the turning rods, and will be stowed in beckets on bulkheads. The tops of rods will be protected by brass caps. Each to be fitted with a lock and key, all keys to be alike. All bar handles will be engraved with name, or cast-brass label plates with polished raised letters will be fixed to adjoining bulkheads.

182. LIFTING GEAR.

Efficient lifting gear, consisting of traveler bars and pulleys, deck beam clamps, turnbuckles, shackles, hooks, eyebolts, as may be directed, will be fitted wherever required for lifting parts of the machinery for overhauling and repairing.

Holes will be tapped in all the principal movable parts of machinery for this purpose.

183. OIL TANKS.

Oil tanks of 400 gallons total capacity, divided as directed, will be fitted where directed, with facilities for filling from deck. They will be made of galvanized wrought iron not less than ⅛ inch thick, and will each have a glass gauge, a manhole and cover near the top, and a locked cock for drawing oil. In the engine room there will be fitted two copper oil tanks of 10 gallons each, and two of 5 gallons each, and in each boiler compartment one of 3 gallons, all with lock cocks. All oil tanks will be fitted with drip pans.

Each of the larger oil tanks will have a hand pump and pipes for filling the smaller tanks.

One galvanized iron tallow tank, with hinged cover, to hold about 50 pounds, will be fitted where directed.

184. WASTE LOCKER.

An air-tight galvanized iron waste locker will be fitted where directed. It will have a capacity of at least 200 pounds, and be provided with a hinged door and a lock.

185. VENTILATORS.

Ventilators, with cowls well above the awnings, will be fitted as may be required.

The ventilators will be of wrought iron, No. 11 B. W. G., butted and single-strapped and flush-riveted. Where cowls are fitted they will be movable, of No. 12 B. W. G. copper, not planished. The base rings of cowls will be of composition, finished on working parts, but left unfinished on the outside. All cowls will be fitted with gear for turning them from the engine and fire rooms, the gear to be of composition except the spindles, which will be of wrought iron. Brass hand wheels or T handles will be fitted to spindles in engine and fire rooms, and wrought-iron jointed handles on deck, so that they may be turned from deck if desired; the latter handles to hang vertically when not in use.

There will be at least one ventilator in each fire room, fitted with all appliances for hoisting ashes.

Fire room ventilators coming near compasses will be made of copper above protective deck.

186. STEAM LAUNCH MACHINERY.

The machinery of the steam cutter will be fitted with boilers and engines which will meet the approval of the Bureau of Steam Engineering, and drawings must be submitted before work is commenced on them.

Duplicate crank pin and crosshead brasses will be supplied, as well as wrenches to fit all nuts, and a set of fire tools.

187. TOOLS.

The following tools will be furnished in addition to those elsewhere specified:

One set of wrenches complete for each engine and each fire room, to be fitted for all nuts in their respective compartments, plainly marked with sizes, and fitted in iron racks of approved pattern. The wrenches for nuts of bolts less than 1 inch in diameter will be finished, and for all over 2 inches in diameter will be box wrenches, where such can be used. Socket wrenches will be fur-

nished where required. Open-end wrenches will be of steel or wrought iron with case-hardened jaws, all others of wrought iron or cast steel.

One pair of taps, on rods, for tapping front and back tube sheets of main boilers at one operation. This will be a duplicate of that used in originally tapping the sheets, and be so packed as to be perfectly protected from injury.

A fixed trammel for setting the main valves without removing the covers; the valve stems to be properly marked for this purpose.

Fixed trammels or gauges for aligning crank shafts, brass pins being let into pillow blocks and center marked for this purpose.

One set of wrenches and spanners for refrigerating engine.

Two complete sets of fire tools for each fire room.

Three coal and three ash buckets.

All trammels and gauges will have protecting cases.

All tools will be conveniently stowed.

188. DUPLICATE PIECES.

The following duplicate pieces, in addition to others specified, will be furnished, fitted, and ready for use, viz:

One set of valves and springs for each main air pump, one for each auxiliary air pump, and one for each independent pump in engine and fire rooms.

One set valve guards and bolts for one main air pump.

One set for each auxiliary air pump.

If horse shoe thrust bearing is used, one set horseshoes for one bearing.

Two bottom brasses and two caps for crank shaft bearings.

Two crown brasses and two butt brasses for crank pins.

Two caps and two butt brasses for crosshead journals.

A full set of blades for each propeller, fitted to propeller bosses; these blades will be of such pattern as may be directed after the trial of the vessel.

One complete set of brasses for each main engine valve gear.

One complete set of brasses for each circulating pump engine, each main feed pump, each fire pump, and each blowing engine.

One piston rod for each piston of each size pump.

One feed check valve complete.

One bottom blow valve complete.

One surface blow valve complete.

One complete set of metallic packing for each size stuffing box in addition to four sets for piston rods.

Four cup leathers for each one used in oil cylinder of reversing engines.

A spare hose and nozzle for each steam tube cleaner.

One-eighth of a complete set of grate bars and bearers for all furnaces, and one pattern for each casting.

One dead plate for furnaces and one pattern for same.

Ten stay tubes, threaded to fit threads in tube sheets, with ends wrapped in canvas.

Twenty-five ordinary boiler tubes, swelled at one end and annealed, ready for use.

One complete set of tubes for one main boiler.

One spare boiler manhole plate of each size, complete with bolts, nuts, and yokes.

Fifty main condenser tubes, packed in boxes.

Fifty condenser-tube glands.

One spare spring for each safety valve, one for each sentinel valve, and one for each cylinder and pump relief valve.

One spare basket for each Macomb bilge strainer.

One set of coils or tubes for evaporator, with steam head.

Wherever duplicate pieces are furnished for one of two or more pieces of machinery of the same size, they will be made strictly interchangeable.

All finished duplicate pieces not of brass, except as otherwise specified, will be painted with three coats of white lead and oil and well lashed in tarred canvas, with the name painted on outside. Brass pieces will be marked or stamped. All pieces will be stowed in an approved manner.

All boiler tubes will be securely stowed in racks, or as directed.

189. MATERIALS AND WORKMANSHIP.

All castings must be sound and true to form, and before being painted must be well cleaned of sand and scale, and all fins and roughness removed.

No imperfect casting or unsound forging will be used if the defects affect the strength or to a marked degree its sightliness.

All nuts on rough castings will fit facings raised above the surface, except where otherwise directed. All flanges of castings will be faced, and those coupled together will have their edges made fair with each other. The faces of all circular flanges will be grooved.

All bolt holes in permanently fixed parts will be reamed or drilled fair and true in place, and the bodies of bolts finished to fit them snugly.

All pipes beneath floor plates will be connected by forged bolts and nuts of rolled manganese or Tobin bronze.

All brasses will fit loosely between collars of shafting.

All brasses or journals will be properly channeled for the distribution of oil.

Packing for stuffing boxes will be such as may be approved.

All small pins of working parts will be well case-hardened.

All steel joint pins of valve gear will be hardened and ground to true cylindrical surfaces.

All material used in the coustruction of the machinery will be of the best quality. The iron castings will be made of the best pig iron—not scrap—except in cylinder liners and where otherwise directed.

Composition castings will be made of new materials.

The various compositions will be by weight, as follows:

For all journal boxes and guide gibs where not otherwise specified: Copper 6, tin 1, and zinc ¼ parts.

Naval brass: Copper 62, tin 1, and zinc 37 per cent.

For composition not otherwise specified: Copper 88, tin 10, and zinc 2 per cent.

Muntz metal will be of the best commercial quality.

Anti-friction metal will be of approved kind.

Ornamental brass fittings will be of good uniform color.

All castings will be increased in thickness around core holes. Core holes will be tapped and core plugs screwed in and locked, except where bolted covers are used, or where it may be directed that the holes be left open.

All steel forgings will be without welds and free from laminations.

All flanges, collars, and offsets will have well rounded fillets.

All boiler plates, stays, and tubes will be well cleaned of mill scale by pickling or other approved means.

All flanged parts of boilers will be annealed, after flanging, in an approved manner.

India rubber valves will be of approved kind, of best commercial quality.

All bolts for securing the boiler attachments will, where practicable, be screwed through the boiler plates, with heads inside.

All work will be in every respect of the first quality and executed in a workmanlike and substantial manner.

Any portion of the work, whether partially or entirely completed, found defective, must be removed and satisfactorily replaced without extra charge.

190. TESTS OF MATERIAL.

All steel used in the construction of the boilers, and all steel forgings and castings, will be tested in accordance with rules prescribed by the Navy Department.

All boiler and condenser tubes will be tested to 300 pounds pressure per square inch, applied internally before being put in place.

India rubber valves, taken at random, must stand a dry-heat test of 270 degrees Fahrenheit for one hour, and a moist-heat test of 300 degrees Fahrenheit for three hours, without injury.

191. TESTS OF BOILERS AND MACHINERY.

Before the auxiliary boilers are painted or placed in the vessel they will be tested under a pressure of 250 pounds to the square inch above atmospheric pressure. This pressure will be obtained by the application of heat to fresh water within the boilers, the water filling the boilers quite full. The main boilers will be tested in the same manner as the auxiliary, but to 360 pounds pressure per square inch.

The steam pipes and valves and all fittings and connections subjected to the main boiler pressure will be tested to 360 pounds to the square inch.

The steam pipes and valves, auxiliary engines, and all connections subjected to the auxiliary boiler pressure will be tested by water pressure to 250 pounds to the square inch.

After the boilers are placed in the vessel and connections are made, the main boilers and pipe connections will be tested by steam to 300 pounds per square inch, and the auxiliary boilers and connections will be tested by steam to 200 pounds per square inch, and all leaks made tight before they are clothed.

The high-pressure cylinders, jackets, and valve chests will be tested by water pressure to 360 pounds to the square inch, the first intermediate-pressure cylinders and connections to 225 pounds, the second intermediate-pressure cylinder and connections to 150 pounds, and the low-pressure to 100 pounds. The exhaust side of the low-pressure valve chests will be tested to 30 pounds. The condensers will be tested to 30 pounds.

The pumps, valve boxes, air vessels, and pipes and valves of all feed pumps will be tested to 450 pounds and of all fire and bilge pumps to 300 pounds per square inch. The cylinders and condensers will be tested before being placed on board, and must be so placed that all parts may be accessible for examination by the Inspector during the tests. All parts will also be tested after being secured on board. No lagging or covering is to be on the cylinders or condensers during the tests. All pressures to be above atmospheric pressure.

The circulating pumps will be tested by discharging water under conditions as nearly as possible like those they will be working under when throwing water from the bilges. They must discharge the water at the same height as the waterline is above the pumps and through the same length and size of pipe, drawing water from the same depth as the lowest part of the bilge suction pipe

below the pump and through the same length and size of pipe.

192. PAINTING.

After a satisfactory test the boilers will be painted on the outside with two coats of brown zinc and oil, and when in place the fronts will be painted with one coat of black paint.

All engine work not finished will be primed with two coats of brown zinc and oil, and when placed in position on board the vessel will be painted with two coats of paint of approved color. The shafting, when in place, will be painted with two coats of red lead and oil and two coats of black paint.

The smoke-pipes will be thoroughly painted before and after erection on board. The ventilators and cowls will be painted similarly to the smoke-pipes, except the interiors of the cowls, which will be painted vermilion.

All pipes will be painted in accordance with a schedule to be hereafter furnished.

193. PRELIMINARY TESTS AND TRIALS.

Steam will not be raised in the boilers until after the water test on board, unless desired for drying or testing joints, for which purpose the pressure must not exceed 10 pounds per square inch.

After testing, steam will be raised in the boilers whenever required to test the connections and the workings of all parts of main and auxiliary engines.

All expense of such preliminary test will be borne by the contractor.

194. SUPERINTENDING ENGINEER'S OFFICE.

A suitable office and a suitable drafting room, properly furnished and heated, will be furnished by the contractor for the use of the superintending naval engineer and his assistants.

195. RECORD OF WEIGHTS.

All finished machinery, boilers, and appurtenances thereof, as fitted, and all spare machinery and tools herein

specified, will be weighed by the contractor in the presence of the superintending naval engineer, or one of his assistants, before being placed on board; and no part of the material will be placed on board without being so weighed, to the satisfaction of the superintending naval engineer.

196. WORKING DRAWINGS.

All drawings necessary for the prosecution of the work must be prepared by and at the expense of the contractor.

Those which are developments of the drawings furnished and of these specifications will be subject to the approval of the Bureau of Steam Engineering before the material is ordered or the work commenced.

Such drawings will be made to scale, with figured dimensions of all parts. If a correction or change is made in any part of a finished drawing, the dimension will be written with the word "marked" after it. Materials will be hatched in accordance with the Bureau standard, or be plainly marked with lettering.

In the drawings furnished, figured dimensions, where given, will be followed, and not scale dimensions, unless otherwise directed. All discrepancies discovered in drawings, or between drawings and specifications, will be referred to the Bureau of Steam Engineering.

A copy of each working drawing will be furnished to the superintending naval engineer before the work shown by the drawing is commenced. A copy of each drawing accompanying orders for steel castings or forgings will also be supplied when the work is ordered.

197. DRAWINGS OF COMPLETED MACHINERY.

The contractor will make and furnish to the Bureau of Steam Engineering, through the superintending naval engineer, a complete set of drawings of the boilers, machinery, and appurtenances as actually completed, including plans of the same as fitted on board the vessel. These drawings will include every piece of machinery, both in whole and in part, and will be in such detail as would enable the entire machinery to be duplicated

without additional drawings. No sheet will contain drawings of more than one part of the machinery, except those intimately connected with each other. The detail drawing of each part of the machinery will be furnished within one month after the completion of the part without waiting for its incorporation into the machine as a whole. Detail drawings will be made to a scale of not less than 1½ inches to the foot. General plans of the machinery in place in the vessel will be made to a scale of ½ inch to the foot.

The pipe plans will be made to a scale of not less than ¾ of an inch to the foot. The pipe plans will be divided into at least two parts—one showing steam and exhaust pipes, and the other showing all other pipes. The pipe plans will be colored in according with a schedule to be furnished, to indicate the purpose which the pipes are intended to serve, and accompanied by an explanatory index.

All drawings will be made on the best quality of tracing cloth; all sheets being, as far as possible, multiples or sub-multiples of double-elephant size.

Detail drawings will be hatched, where in sections, in accordance with a schedule to be furnished, to show the various metals employed.

198. CHANGES IN PLANS AND SPECIFICATIONS.

The contractor will make no changes in the plans or specifications without the approval of the Navy Department. In case it is thought advisable to make changes, the contractor will make application by letter to the Bureau of Steam Engineering, through the superintending naval engineer, stating the nature of the change, accompanied by complete plans and specifications of the proposed change, together with a statement of his estimate of the amount of increase or decrease in cost.

199. INSPECTION.

The work of construction of the boilers, machinery, and appurtenances shall be at all times open to inspection by officers appointed for such purpose by the Navy

Department. Every facility will be afforded such inspectors for the prosecution of their work. All handling of material necessary for purposes of inspection will be done at the expense of the contractor. All test specimens necessary for the determination of the strength of material used will be prepared and tested at the expense of the contractor. The contractor will furnish the superintending naval engineer with a weekly list of the number of men of each class employed upon the work, together with a statement of the number of hours' labor in each class.

200. OMISSIONS.

Any part of the machinery or any article pertaining thereto which may have been inadvertently omitted from these specifications or from the official drawings, but which is necessary for the proper completion of the vessel, is to be supplied by the contractor without extra charge.